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THE BRIDGEWATER TREATISES

ON THE

POWER, WISDOM, AND GOODNESS OF GOD, AS MANIFESTED IN THE CREATION.

TREATISE II.

ON THE ADAPTATION OF EXTERNAL NATURE TO THE PHYSICAL CONDITION OF MAN.

BY J. KIDD, M.D.

THOU MADEST HIM TO HAVE DOMINION OVER THE WORKS OF THY HANDS ;
THOU HAST PUT ALL THINGS UNDER HIS FEET.

PSALM VIII. 6.

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ON THE

ADAPTATION OF EXTERNAL NATURE

TO THE

PHYSICAL CONDITION OF MAN,

PRINCIPALLY

WITH REFERENCE TO THE SUPPLY OF HIS WANTS, AND THE EXERCISE
OF HIS INTELLECTUAL FACULTIES.

BY

JOHN KIDD, M.D. F.R.S.,

REGIUS PROFESSOR OF MEDICINE IN THE UNIVERSITY OF OXFORD.

A NEW EDITION.

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HIS GRACE

THE ARCHBISHOP OF CANTERBURY.

MY LORD,

Having been appointed to write the following Treatise by the late President of the Royal Society, in consequence of your Grace's recommendation, it was natural that I should be desirous of publicly acknowledging the high honour thus conferred upon me.

I therefore request you to accept my respectful thanks for permitting me to inscribe this Treatise with your Grace's name: assuring you that, however inadequately I may have been found to answer your expectation in the execution, I have not applied myself to the task committed to me, without the exertion of much thought, and the strongest desire of so executing it, as to justify your Grace's favourable opinion.

I have the honour to be,
My Lord,
with the greatest respect,
Your Grace's most obliged
and obedient Servant,
J. Kidd.

Oxford, March 15, 1833.

PREFACE.

The occasion which gave rise to this and the accompanying Treatises is explained in the following notice: but the Author of the present Treatise thinks it right to add, that, although encouraged by the honour of having been recommended by His Grace the Archbishop of Canterbury, he should have shrunk from his present attempt, had he considered that any exact elucidation of the details of science was required in the execution of it.

As, however, the intention of Lord Bridgewater, and the very extent and diversified nature of the subject, seemed to him almost necessarily to exclude any great exactness of elucidation, and to require a popular rather than a scientific exposition of facts; and as the whole tenour of his pursuits during the last thirty years of his life accorded with the character of the proposed subject; he the more readily undertook a task, to the execution of which he could not but look forward with much pleasure. And if he should in any instance stimulate the reader to examine the question with any portion of the interest and satisfaction with which he has himself examined it, he is confident that he shall not have laboured in vain.

It will be for others to determine whether a judicious selection and a sufficiently natural arrangement of the materials of the following Treatise have been adopted: but to those, who may think that many of the subjects have been treated too cursorily, the Author begs leave to point out the extensive range afforded by so wide a field of inquiry; and the consequent necessity of compression in each particular; the subject of this Treatise being in fact an epitome of the subjects of almost all the others. He also considers it right to state, that it is the immediate object of the Treatise itself to unfold a train of facts, not to maintain an argument; to give a general view of the adaptation of the external world to the physical condition of man, not to attempt formally to convince the reader that this adaptation is a proof either of the existence and omnipotence of the Deity, or of his beneficence and wisdom; though undoubtedly it is hoped by the writer, as it was intended by the munificent individual who originally proposed the general subject of this and the accompanying Treatises, that such a conviction, if not already existing, may be produced by its perusal. Without questioning, therefore, on the present occasion, the intellectual powers or the moral motives of those who profess themselves sceptics with respect to either natural or revealed religion, the Author addresses himself exclusively to those who are believers in both the one and the other. With respect indeed to a disbelief in the basis of natural religion, he must ever feel assured, as in another place he has expressed himself, that, however easy it may be to account for the external profession of a disbelief in God, the supposition of the existence of intellectual atheism involves an intellectual absurdity. With respect to the truth of Revelation, although the subject of this Treatise is not directly connected with that question, he would still wish to consider himself as addressing those only who with himself believe that the objects which surround us in our present state of existence, and which are so obviously intended to advance the general powers and faculties of *Man*, without advancing the powers and faculties of any other animal, are purposely destined to produce an ulterior and higher effect; the nature of which effect is to be learnt from the doctrines of Revelation alone. And he has thought it right to say thus much on the general subject of religion, not merely for the purpose of recording his own sentiments; but that, in professing to address those only who believe in revealed as well as in natural religion, if on any occasion he should assume the truth of Revelation, he may not be with justice accused of taking that for granted, of which the reader doubts.

NOTICE.

The series of Treatises, of which the present is one, is published under the following circumstances:

The Right Honourable and Reverend Francis Henry, Earl of Bridgewater, died in the month of February, 1829; and by his last Will and Testament, bearing date the 25th of February, 1825, he directed certain Trustees therein named to invest in the public funds the sum of Eight thousand pounds sterling; this sum, with the accruing dividends thereon, to be held at the disposal of the President, for the time being, of the Royal Society of London, to be paid to the person or persons nominated by him. The Testator further directed, that the person or persons selected by the said President should be appointed to write, print, and publish one thousand copies of a work *On the Power, Wisdom, and Goodness of God, as manifested in the Creation; illustrating such work by all reasonable arguments, as for instance the variety and formation of God's creatures in the animal, vegetable, and mineral kingdoms; the effect of digestion, and thereby of conversion; the construction of the hand of man, and an infinite variety of other arguments; as also by discoveries ancient and modern, in arts, sciences, and the whole extent of literature.* He desired, moreover, that the profits arising from the sale of the works so published should be paid to the authors of the works.

The late President of the Royal Society, Davies Gilbert, Esq. requested the assistance of his Grace the Archbishop of Canterbury and of the Bishop of London, in determining upon the best mode of carrying into effect the intentions of the Testator. Acting with their advice, and with the concurrence of a nobleman immediately connected with the deceased, Mr. Davies Gilbert appointed the following eight gentlemen to write separate Treatises on the different branches of the subject, as here stated:

THE REV. THOMAS CHALMERS, D. D.

PROFESSOR OF DIVINITY IN THE UNIVERSITY OF EDINBURGH.

ON THE ADAPTATION OF EXTERNAL NATURE TO THE MORAL AND INTELLECTUAL CONSTITUTION OF MAN.

JOHN KIDD, M. D. F. R. S.

REGIUS PROFESSOR OF MEDICINE IN THE UNIVERSITY OF OXFORD.

ON THE ADAPTATION OF EXTERNAL NATURE TO THE PHYSICAL CONDITION OF MAN.

THE REV. WILLIAM WHEWELL, M. A. F. R. S.

FELLOW OF TRINITY COLLEGE, CAMBRIDGE.

ON ASTRONOMY AND GENERAL PHYSICS.

SIR CHARLES BELL, K. H. F. R. S.

THE HAND: ITS MECHANISM AND VITAL ENDOWMENTS AS EVINCING DESIGN.

PETER MARK ROGET, M. D.

FELLOW OF AND SECRETARY TO THE ROYAL SOCIETY.

ON ANIMAL AND VEGETABLE PHYSIOLOGY.

THE REV. WILLIAM BUCKLAND, D. D. F. R. S.

CANON OF CHRIST CHURCH, AND PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF OXFORD.

ON GEOLOGY AND MINERALOGY.

THE REV. WILLIAM KIRBY, M. A. F. R. S.

ON THE HISTORY, HABITS, AND INSTINCTS OF ANIMALS.

WILLIAM PROUT, M. D. F. R. S.

ON CHEMISTRY, METEOROLOGY, AND THE FUNCTION OF DIGESTION.

His Royal Highness the Duke of Sussex, President of the Royal Society, having desired that no unnecessary delay should take place in the publication of the above-mentioned treatises, they will appear at short intervals, as they are ready for publication.

CONTENTS.

CHAP. I. INTRODUCTION - - - - - - 13
- SECT. I. The Physical Condition of Man - - - - 13
- II. The general Constitution of external Nature, - - 14

CHAP. II. THE PHYSICAL CHARACTER OF MAN - - - 17
- SECT. I. The Physical Character of Man, compared with that of other animals - - - - - - - - 17
- II. Differences in the Form of the Infant and of the Adult; particularly with reference to the Spine - - - 18
- III. Physical Superiority of Man, on what Principle to be estimated - - - - - - - 21
- IV. Early and gradual Developement of the intellectual Faculties of Man - - - - - - 23

CHAP. III. ON THE POWERS OF THE HUMAN HAND, CONSIDERED AS A CORPOREAL ORGAN - - - - - - - 26

CHAP. IV. ON THE BRAIN, CONSIDERED AS THE ORGAN OF THE INTELLECTUAL FACULTIES - - - - - - - 32

CHAP. V. THE NERVOUS SYSTEM OF ANIMALS IN GENERAL - - 35
- SECT. I. The Nervous System of the inferior Animals - - 35
- II. The Nervous System of Man - - - - 37
- III. Indications of natural Talent and Disposition deducible from the Structure of the Brain - - - - 40
- IV. The general Doctrine of Physiognomy, as connected with the Form of the Body - - - - - 44
- V. The Developement of the Human Brain, compared with that of other Animals - - - - - 47
- VI. Cursory View of the Extent of Human Power over the Objects of the external World - - - - 48

CHAP. VI. ADAPTATION OF THE ATMOSPHERE TO THE WANTS OF MAN - 51
- SECT. I. The general Constitution of the Atmosphere - - 51
- II. Light - - - - - - - 52
- III. Heat - - - - - - - 58
- IV. The general Uses of Water - - - - 63
- V. Baths - - - - - - - 66
- VI. The Fluidity of Water - - - - - 68
- VII. The natural Sources of Water - - - - 71
- VIII. The Air of the Atmosphere, as connected with Respiration 72

IX. Effects of the Motion of the Air, as connected with Human Health, &c. - - - - - - 75
X. Effects of the Motion of the Air, as connected with the Arts, &c. - - - - - - 80
CHAP. VII. Adaptation of Minerals to the Physical Condition of Man - - - - - - - 85
Sect. I. The general Characters of Minerals - - - 85
II. Application of Minerals to Architecture and Sculpture - 86
III. Gems and precious Stones - - - - 92
IV. The Distribution and relative Proportions of Sea and Land; and the geological Arrangement and physical Character of some of the superficial Strata of the Earth - - 95
V. Beds of Gravel - - - - - - 96
VI. Metals - - - - - - - 101
VII. Common Salt, &c. - - - - - 107
CHAP. VIII. Adaptation of Vegetables to the Physical Condition of Man - - - - - - - 108
Sect. I. General Observations on the Vegetable Kingdom - - 108
II. The Cocoa-nut Tree, including the Formation of Coral Reefs 109
III. Vegetables as a Source of Food - - - - 115
IV. Vegetables as applicable to Medicine - - - 119
V. Vegetables as applicable to the Arts, &c. - - - 122
CHAP. IX. Adaptation of Animals to the Physical Condition of Man - - - - - - - 128
Sect. I. General Observations on the Animal Kingdom - - 128
II. Geographical Distribution of Animals - - - 130
III. The Camel - - - - - - 131
IV. Domestication of Animals - - - - - 135
V. Animals as a Source of Food - - - - 138
VI. Manufacture of Sal Ammoniac - - - - 139
VII. Animals as a Source of Clothing, &c. - - - 141
CHAP. X. Adaptation of the external World to the Exercise of the Intellectual Faculties of Man - - - 142
Sect. I. On the Rise and Progress of Human Knowledge - - 142
II. Opinions of Lucretius on the constitution of Matter in general; and on the Nature of Light, Heat, Water, and Air 148
III. Opinions of the Ancients on the Organization and Classification of Animals - - - - - 154
IV. On those Animal Forms called Monsters, or Lusus Naturæ 171
CHAP. XI. Conclusion - - - - - - 173
Appendix - - - - - - - - 176

ON THE

ADAPTATION OF EXTERNAL NATURE

TO THE

PHYSICAL CONDITION OF MAN.

CHAPTER I.

INTRODUCTION.

SECTION I.

The Physical Condition of Man.

When Hamlet, in contemplating the grandeur of creation, breaks forth into that sublime apostrophe on man—"How noble in reason! how infinite in faculties! in form and moving, how express and admirable! in action, how like an angel! in apprehension, how like a God! the beauty of the world! the paragon of animals!"—who does not feel elated by the description? who does not feel conscious of its truth?

Nor is its truth the less admissible, because the poet, in concentrating the powers of his imagination on the excellences of that work of creation which bears the stamp of the Creator's image, has omitted to present to our view the reverse of the impression, the frailty namely of our fallen nature: for although, on moral and religious considerations, each individual is bound habitually to take the one view in conjunction with the other; in a simple philosophical contemplation of human nature we are not precluded by any reasonable barrier, from taking such a partial view of the subject as the occasion may suggest.

In the present instance, indeed, I am strictly called upon to consider, not the moral, but *the physical condition of man:* and to examine how far *the state of external nature is adapted* to that condition; whether we regard the provisions made for *the supply of man's wants, either natural or acquired;* or those which are made for *the* *exercise of his intellectual faculties.* The following treatise naturally, therefore, divides itself into two parts: in the first of which it is intended to investigate and describe the physical condition of man; in the second, the adaptation of external nature to that condition.

But a wide field here opens to our view: for man cannot, under any circumstances, be considered as an insulated being; or unconnected with the rest of animated nature. He is indeed but one link in the great chain of animal creation; and not only does the contemplation of his condition lose half its interest, if separated from the contemplation of the condition of other animals; but it cannot be satisfactorily investigated without that aid. And, again, animal life itself is but one among many modes of existence, by which the Creator has manifested his omnipotence; and which it is necessary to contemplate in connexion with the general phenomena of nature, in order to show the superiority of that province, at the head of which human beings have been placed.

In attempting however to form a just estimate of the physical condition of man, we must not regard him merely under the aspect of savage or uncivilized life, and consider this as his natural state: for it may be presumed that, at the present day, such a puerile view of the question is not for a moment entertained by any one capable of philosophical reflection. In fact, in as many different states as man does actually exist, civilised or savage, so many are his natural states. If any indeed could be pre-eminently called his natural state, it would be that of civilization: for not only does experience show that his natural tendency is towards such a state; but we know, from the highest authority, that the existence of man is connected with a moral end; (with more indeed than a moral end; since morals have immediately a relation to this life only, while man is destined for a future;) and a moral end is hardly attainable in an uncivilized state of society.

Section II.

The general Constitution of external nature.

The more familiar objects of that external world by which man is surrounded are usually distributed into three kingdoms, as they are called; the *animal*, *vegetable*, and *mineral:* but for the purpose of this treatise it will be necessary to take into our account the phenomena of the *atmosphere* also.

The *atmosphere* principally consists of the *air* which we respire; (a form of matter so subtle, in all its states, as to be invisible;) together with a variable proportion of *water*, of which a part is always retained in close combination with the air; and, like the air itself, exists always in an invisible state. There are also diffused through the atmosphere those still more subtle agents, *heat* and *electricity.* But all these, though of so subtle a substance, are in their occasional effects the most powerful agents of nature. For, omitting the consideration of their silent but wonderful operation, as exhibited in the process of vegetation, and in many other processes less open to observation, let us consider the occasional effects of air in the violence of a tornado; or of water, in the inundation of a rapid river: or let us contemplate the effect of either an indefinite diminution or increase of heat; on the one hand, the natural process of animal decomposition arrested by its abstraction, so that the imbedded mammoth remains at this moment in the same state that it was four thousand years ago; and in which, under the same circumstances, it undoubtedly would be, four thousand or four million years hence; on the other hand, the possibility of the dissipation of all the constituent parts of matter, or their fixation in the state of glass, resulting from the agency of indefinitely increased heat: or, lastly, let us consider the tremendous effects of condensed electricity in the form of lightning:—and we shall necessarily acknowledge that though in their usual state the constituents of the atmosphere are among the most tranquil agents of nature, yet, when their power is concentrated, they are the most awfully energetic.

In the *mineral kingdom* the most characteristic property of the several species appears to be a disposition to a pecular mode of mutual attraction among the particles composing the individuals belonging to them; from which attraction, when exerted under the most favourable circumstances, result that symmetry and regularity of form, to which the term *crystal* has been applied. The transparency and degree of hardness of crystals are various, and depend much upon external circumstances. The form is fundamentally the same for each species, though capable of being modified according to known laws; and the substance is chemically the same throughout its whole extent. Every atom of a crystallized mass of gypsum consists of water, lime, and sulphuric acid, united in the same proportions as are found to exist in the whole mass, or in any given part of it.

The individuals of the *vegetable kingdom* differ very remarkably from those of the mineral, both in form and substance. In their form we see nothing like the mathematical precision of crystallization; and in their substance they differ widely, according to the part of the vegetable which is examined: so that, independently of previous knowledge of the species, we could hardly discover any natural relation between the several constituent parts of the individual. What is there in the insulated leaf of a rose or of a peach tree, that would lead us to expect the fruit of the one or the flower of the other? But the most remarkable line of distinction between vegetables and the individuals of the preceding kingdom consists in their mode of increase and reproduction. Minerals can only increase, as such, by the apposition of particles specifically similar to themselves; and can only be originally produced by the immediate combination of their constituent elements. But vegetables have an apparatus within them, by means of which they can assimilate the heterogeneous particles of the surrounding soil to their own nature; and they have also the power of producing individuals specifically the same as themselves: in common language, they are capable of contributing to their own growth, and to the continuation of their species. And as they produce these effects by means of internal organs adapted to the purpose, they are hence denominated organized bodies.

The individuals of the *animal kingdom* very closely resemble those of the vegetable in the two properties just described. The respective organs differ, as we might expect, in their form and position; but in their functions or mode of action there is a strong analogy, and even similarity, throughout. But animals differ from vegetables more remarkably than these do from every unorganized form of matter, in being endued with sensation and volition; properties which extend the sphere of their relations to such a degree, as to raise them immeasurable above all other forms of matter in the scale of existence.

In distributing the individuals of the material world among these four kingdoms of nature, there occasionally prevails considerable obscurity, not only with respect to the true place which an individual ought to occupy in the scale of a particular kingdom; but even with respect to the question, under which of the four kingdoms it ought to be arranged; this obscurity arising of course from the points of resemblance apparently balancing, or more than balancing, the points of difference. Let us for instance, in the atmospherical kingdom, take a fragment of a perfectly transparent crystal of pure ice; and, under ordinary circumstances, it would be difficult, either by the sight or the touch, to distinguish it from a fragment of transparent quartz, or rock crystal: indeed the transfer of the original term κρύσταλλος, from the one to the other, shows the close resemblance of the two. Some minerals again so nearly resemble vegetables in form, as to have given rise to specific terms of appellation, derived from the vegetable kingdom; as *flos ferri*, *mineral agaric*, &c. And, lastly, many of the animals called sea-anemones so far resemble the flower called by the same name, that their real character is at first very doubtful to those who are unacquainted with the animals of that genus. But, omitting these rare and equivocal instances, and avoiding the confinement of abstract definitions, we may safely affirm that, of all the kingdoms of nature, the individuals of the animal kingdom have the most extensive and important relations to the surrounding universe. And I need not here insist on the obvious inference, that if among the kingdoms of nature animals hold the first rank, in consequence of the importance of these relations, among animals themselves the first rank must be assigned to man.

CHAPTER II.

THE PHYSICAL CHARACTER OF MAN.

SECTION I.

The Physical Character of Man, compared with that of other Animals.

ALTHOUGH, when viewed in the aggregate of his faculties, moral as well as physical, man confessedly holds the first rank among animals; yet, if we exclude from our consideration those intellectual powers and moral qualities by which he is essentially characterised, and confine our view to his mere animal nature, we find that he scarcely differs in any important point from any of the species of the higher classes. In each there is the same necessity for air, and sleep, and food; and the nature of the food and the mode of its digestion are not materially different: the nutrient fluid extracted by the process of digestion is converted into blood of the same character, and distributed in the same manner through the system; the constituent parts of the body and their mode of growth are almost precisely the same; for the bone, muscle, tendon, skin, hair, and brain of the horse, or deer, or tiger, or bear, scarcely differ in their physical or chemical characters from the correspondent parts in man: similar secretions, as the bile, tears, and saliva, are separated by similarly constructed organs; and similar parts become similarly diseased: the special senses of sight, hearing, taste, and smell, are exercised through the medium of similar organs, simply modified according to the particular wants of individual species: the sources of mere bodily pain or pleasure are generally the same: the instinctive affections, passions, and propensities are the same, and are manifested in the same way; the angry look of a dog, for instance, bespeaking the internal feeling as strongly as that of the man; and the playful and rapid movements of the young puppy resembling the careless hilarity of childhood, no less than the stayed motions and wary eye of the aged hound resemble the sedateness of the aged human being.

Probably, however, it would be nearer the truth, were we to say that man, if divested of his intellectual powers, and endued merely with his animal nature, would be inferior to the brutes; for, possessing, as is the case, very few of the prospective or preservative instincts, he would be unable, without the aid of his intellectual powers, to provide for some of his most imperious wants.

But we may go even further than this. Let us suppose, for instance, a community of human individuals, who, though not gifted with a sufficient degree of intellectual powers to instruct others, or improve themselves, were yet endued with them to a degree sufficient to render them, if the opportunity offered, docile to a certain extent, and capable of executing many of the common offices of life; (and what town or village does not present to our observation individual instances of such unhappy shadows of human nature?) how could a community like this exist; in which, though all, by the terms of the supposition, were capable of learning something, yet none would be capable of teaching anything? of what use under these circumstances would be that "instrument of instruments" the human hand, where there was no presiding mind to direct its movements? And, with respect to that wonderful auxiliary of the human powers, how incorrect is the reflection of those who have asserted that men are superior to brutes, only because they possess this instrument: and how truly philosophical is the opposite reflection, that man is not superior to other animals because he possesses this instrument; but he is provided with such an instrument precisely because he is already superior to all other animals. And the converse is equally true, that, with intellectual powers of even a higher order than those which they already possess, human beings could not live in a state of society, could hardly indeed exist in any state, unless furnished with such an instrument as the hand.

Section II.

Differences in the Form of the Infant and of the Adult; particularly with reference to the Spine.

And yet, notwithstanding the confessed superiority of man, if we view him only in the infancy of his individual existence, what is there that is calculated to give an earnest of his future vigour and activity, either with respect to bodily or mental powers; and what are all the advantages of the external world to a creature so utterly helpless, so utterly incapable of using or even passively enjoying them? In fact, with the exception of a very few instinctive rather than voluntary acts, such as that of deriving its nutriment from the mother's breast, the infant is, from the feebleness of its powers, incapable of efficient exertion; and depends entirely on the assistance of those around it.

The physical differences, observable in comparing the structure of the infant with that of the adult, which enable the one to execute many operations of which the other is incapable, exist to a certain extent in every part of the body; but are perhaps more remarkable in the spine than in any other part: and the spine therefore may be selected as a fit term of comparison.

In considering the office of the adult spine, with a view to the present subject, we find that great strength, combined with great flexibility, is particularly requisite. With reference to strength, the pyramidal form of this natural column is obviously conducive to the purpose intended; and the arrangement of the solid matter, of which it is composed, is such as to contribute to the same effect; for that solid matter, instead of being collected into one compact mass, is diffused in such a manner as to resemble the structure of sponge; and it is well known, with reference to the strength of artificial columns, that, the same quantity of matter being given for each, and their height being the same, those columns which are hollow are stronger than those which are solid. Again, the whole column is made up of numerous parts, called vertebræ, which are so firmly bound together as to lessen the chance of being broken in the act of bending; and these vertebræ being applied to each other, throughout, by broad horizontal surfaces, are thus best calculated to support the perpendicular pressure of the superincumbent parts. The effect of general strength is further accomplished by the mutual locking in of the projecting portions, or processes, of the several vertebræ; and the same effect is accomplished to an additional extent among those vertebræ which belong to the thorax or chest, by the mode of articulation between them and the ribs; each rib being united, not entirely to a single vertebra, but partially to two contiguous vertebræ, near their line of junction.

The flexibility of the spine is secured to the utmost requisite extent, by the great number of articulations or joints which it possesses, amounting to more than twenty; as well as by the elasticity of the substance constituting those joints: and the projecting parts or processes of the several vertebræ, which serve for the insertion of the muscles and tendons which are to move the whole, are differently disposed in the neck, the back, and the loins; so as to be accommodated to the degree and kind of motion required in each: thus the vertebræ of the neck admit of a lateral motion to a greater extent than those of the back; and the vertebræ of the back admit of flexion and extension to a greater degree than those of the neck; while the vertebræ of the loins, being intended for support rather than flexibility, have their processes so distributed, as to contribute principally to the former of those effects.

Thus far we have considered the conditions of the adult spine, and have seen that they are calculated most admirably both for flexibility and for strength. Let us now examine the same column in the age of early infancy; and here we shall see, that, although at that period the parts, in which the conditions of strength and flexibility are so remarkably developed in the adult state, are not yet formed, or not completed; those parts which are essential to the security of the life of the individual are nearly in as perfect a state as at the age of manhood: so that in the midst of the most decided marks of weakness and imperfection in the rest of the column, there is an extraordinary instance of strength and perfect growth, in precisely that part of it which could not have been left in an incomplete state, without manifest, immediate, and constant danger to the individual. In other words, the bodies and processes of the several vertebræ on which the strength and flexibility of the spine depend, are in early infancy still in a soft or cartilaginous state; while the annular portions, which with their intervening ligaments constitute the spinal canal, are completely ossified; so as to give as great a degree of security to the spinal marrow as at the age of manhood.

Nor need we spend much time in ascertaining the final cause of this remarkable difference. Is it not indeed obvious on a moment's reflection, that the very helplessness and imperfect state of the physical powers in infancy, so ill understood and appreciated, though so beautifully described by Lucretius, contribute to the fuller developement of the moral character, not only of the individual, but of his parents also, and of all his immediate connexions. The mutual affection, for instance, that takes place and is cemented between the infant and its mother, during the lengthened period in which the latter nurses her offspring; the stimulus, which is given to the exertions of the other parent in supplying the increasing wants of those who depend on him for support; and the general feeling and expression of good-will and attachment, which bind together the numerous individuals of the same family; all coincide to increase the sum of human happiness and virtue. Whereas, were the infant born with all its powers complete, and capable of exerting those powers as soon as born, independently of the assistance of parent, or sister, or brother; what would then remain of those endearing relations, but the empty name?

How incorrect then is the conclusion of the poet in that otherwise most beautiful passage of his poem! "The new-born babe, which like the shipwrecked mariner, lies prostrate on the ground, naked and destitute of every assistance required for the support of life, pierces the surrounding air with its incessant cries; as if foreseeing the long train of miseries which it must hereafter encounter. And yet the tender foal and lamb not only begin to crop the grass, but play about the mother almost as soon as born. The nurse's soothing lullaby is not wanted by them, nor the excitement of the rattle or of any other toy: nor do they require a change of dress accommodated to the changing temperature of the surrounding atmosphere; nor arms for their defence, nor walled cities for their protection; kind nature supplying to them in bountiful profusion whatever is necessary to satisfy their wants."* As if it might not have been reasonably and safely concluded, that that same power, (call it "nature," or by any other name,) which provided so amply for the early wants of the lower species of animals, had some good and special reason for leaving the human infant in a temporary state of helpless weakness.

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* Tum porro Puer, ut sævis projectus ab undis
Navita, nudus humi jacet, infans, indigus omni
Vitali auxilio, cum primum in luminis oras
Nixibus ex alvo matris natura profudit;

Section III.

Physical Superiority of Man, on what Principle to be estimated.

From this helplessness in his early years, and from the occasional inferiority of some of his physical organs to the corresponding organs of brutes, it has sometimes been absurdly asked what claim man has, from his physical structure or powers, to be placed first in the scale of animal beings. His strength, what is it to that of the elephant or of the horse, or even of some species of reptiles or fish? his powers of sight and motion, what are they to those of the bird? his sense of odours, to that of the dog? his touch, to that of the spider?

And yet, even if we entirely omit the consideration of the soul, that immaterial and immortal principle which is for a time united to his body, and view him only in his merely animal character, man is still the most excellent of animals. How confined are the powers of other animals, considered generally, when compared with those of the human species. The comb of the bee indeed is in its construction wonderful; and so is even the nest of the bird, or the habitation of the beaver: but these animals could never be taught to fabricate, or to use, the simplest of those machines or instruments, which man, even in a very partially civilized state, is in the daily habit of making and employing: much less could they be taught to perform those complicated operations which result from their employment.

But, it may perhaps be said, it is the mind, the intellectual power of man, which enables him to produce the effects in question. His mind indeed enables him to conceive the plan of those operations which he executes, but it does no more: and were his form deficient by one of the smallest of its present members, he would be rendered nearly helpless. Take from his hand but one of the fingers, and he could do nothing. It is the human hand which gives the power of execution to the human mind; and it is the relative position of one of the fingers to the other four, which principally stamps the cha-

Vagituque locum lugubri complet, ut æquum 'st,
Cui tantum in vita restet transire malorum.
At variæ crescunt Pecudes, Armenta, Feræque;
Nec crepitacula eis opu' sunt, nec cuiquam adhibenda 'st
Almæ nutricis blanda atque infracta loquela:
Nec varias quærunt Vesteis pro tempore Cœli.
Denique non Armis opus est, non Mœnibus altis,
Queis sua tutentur, quando omnibus omnia large
Tellus ipsa parit, naturaque dædala rerum.
Lib. V. 223—235.

racter of the hand; for the thumb, by its capability of being brought into opposition with each of the other fingers, enables the hand to adapt itself to every shape; and gives it that complete dominion which it possesses over the various forms of matter.*

Give all the intelligence therefore that you please to the horse, or to the elephant, yet with hoofs instead of hands it is physically impossible that they could construct the simplest instrument: nor could the organs even of the beaver, were that animal gifted with the highest intellectual powers, enable it to effect much more than it is capable of effecting at present.

Man then is in every sense superior, in organization as well as in intellectual powers, to all other animals; and the degree of resemblance to him, as thus superior, is the main principle of classification adopted at the present day: and upon the whole it will be found that, in proportion as the powers and relations of animals are extensive, their structure resembles that of man. And, with respect to the degrees of this resemblance, it may be observed that occasionally it is so strong, as to constitute all but identity of form, as in some quadrumanous animals, or apes; while in others it is so faint, as to render it questionable whether we are viewing an animate or inanimate body, as in several varieties of sponge. It is evident that the stability of the principle of classification, now described, depends on the permanency of the specific form of animals: and it will be found that nature has guarded this point in so sacred a manner, that after the lapse of thousands of years, the identity of the species may be not only traced, but demonstrated, when nothing but the almost mouldering bones of the individual remain. But this subject will be considered more at large hereafter.

As then, in estimating the moral or intellectual characters of particular men, we are not influenced by the consideration of insulated defects or excellences, but of the aggregate powers and qualities of the individual; so, in comparing other animals with man, we ought not to affirm that they approach nearer to the standard of his perfection in proportion as they approach nearer to him in the structure of this or that part, or in the developement of particular powers or qualities; but in proportion to that approximation which results from the balance of their structure and powers considered collectively. And on this principle, however nearly a few of them may resemble him, they never can approach even the confines of an equality of nature; whatever some speculative individuals have presumptuously supposed, or others in their simplicity have feared. Thus the resemblance to the human form, as well internally as externally, is so remarkable in particular species of the ape, that while some philosophers (who however proceeded without a knowledge, or a due consideration of the true principles of the science concerned in their reasonings) have maintained that the ape and man are but varieties of the same species, or at most but different species of the same genus; others, with an unnecessary anxiety, have laboured to vindicate the supposed insult thus offered to the dignity of human nature, by searching for some fixed and invariable difference in the structure of the orresponding parts of each.

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* The term *poltroon*, if not of fancied etymology, (*pollice truncatus*,) verifies this statement; the Roman soldier who had been deprived of his thumb, being deemed unfit for service.

But the question is puerile: for let us even suppose that the whole and every part of the structure of the ape were the same as that of man; let every bone, and every muscle, and every fibre of the one correspond exactly with those of the other, not only in form and situation, but also in size and proportion; let the brain itself, that tangible instrument of the intellectual powers, be in structure the counterpart of the human; yet, unless in its functions it resembled that of man, in other words, unless there were associated with it his intellectual peculiarities and the moral and religious sense, to what dreaded conclusion would the closest resemblances lead? However near the approximation in their form, in their nature, there must ever be an immeasurable distance between the two. The ape, compared with man, may indeed be among other animals "proximus huic;" still however it must be added, "longo sed proximus intervallo."

Section IV.

Early and gradual Developement of the inellectual Faculties of Man.

The helplessness of infancy then is but temporary: and a new scene soon opens to the contemplation of those who have sufficient opportunities of watching the developement of the human character: for, long as is the period, compared with the natural term of his own life, and longer still, compared with the corresponding period in the life of other animals, before man attains the full stature of his mind as well as of his body; he at a very early season begins to manifest the superiority of his intellectual nature: he very soon begins to collect those materials for future use, which, though he will never hereafter be able to call to mind the moment or the circumstances of their accession, he will use as effectually as if he had originally acquired them by industrious and direct attention.

It does not fall within the intention of this treatise to attempt to ascertain the period when the first dawn of intelligence enlightens the countenance of the infant; but, undoubtedly, among its earliest beams are those expressive smiles, which, although they are occasioned by the aspect of the mother, and are perhaps only connected with the expectation of an animal pleasure, namely the simple enjoyment of nourishment, yet are soon elicited by other individuals also, who may understand how to win the attention, and amuse the faculties of the infant mind.

It seems as if there were implanted in the young of all animals, of the higher orders, an instinctive propensity to those actions which are naturally determined by their specific form when fully developed; in order perhaps, among other purposes, to give occasion for that exercise of the limbs which is necessary to the health of the individual. Hence the young ram couches his head, and tilts his adversary, long before his horns have appeared; and the young pheasant assails his antagonist with his projected legs, long before his spurs have begun to bud. And, following this analogy, may we not reasonably suppose that the sports of childhood have a natural tendency to prefigure the occupations of manhood; and that by the extension of the same principle, independently of the impulse given by systematic education, or spontaneous imitation of their parents and others, there are instinctive differences in the amusements of children of different temperaments, connected with their future destinations in life? Thus while the boy is engaged in the mimicry of military parade or equestrian exercises, the girl devotes her time to more feminine occupations, and busies herself in acting the various duties which her nursery or household will hereafter require. The recorded attempt to conceal Achilles in female attire, whether founded in fact, or, as is probable, merely a fictitious anecdote, will serve to illustrate the present point; inasmuch as the use of the means, said to have been employed by Ulysses to detect the hero, was evidently suggested by the principle just now advanced.

At this early period of life then, the judgment being not sufficiently matured for deeper observation, the mind is satisfied with a view of the form and surface of objects presented to it; with their anatomy, as it were, rather than with their physiology: but, in the mean time, it is thus acquainting itself undistractedly with those sensible qualities with which it must necessarily be familiar before it can proceed to reason on causes and relations. And although it may appear at first view that a very disproportionately long period of our life is devoted to the mere exercise of the senses, it is yet highly probable that important mental operations may be simultaneously going on, though we are at the time unconscious of them: for something analogous is observable throughout the whole course of our existence. How few there are, for instance, who, at any period of life, can call to mind a tenth part of what they have even recently heard or observed. And if this may be correctly affirmed of the adult age of life, and of those individuals whose original powers of mind are great, how much more strongly will it apply to those whose original powers of mind are not above the common standard, or not yet matured by age. So that there can be very little doubt that the general principles and rules, which regulate the reasoning and conduct of men on ordinary occasions, have been originally deduced by each individual from much of what has been long forgotten.

It has been asserted by persons,* whose intellectual powers were of the highest order, and whose industry was as remarkable as their abilities, that more than six or eight hours in each day could not be employed effectively by the generality of young men for the purpose of mental improvement. If this however be the case, and as a general position it probably is not very far from the truth, in vain does the ambitious student rob nature of that sleep which Providence has made necessary for the renovation of the exhausted powers of our mind, as well as of our body; and in vain also does he attempt to combine simultaneously the efforts of mental attention with bodily exercise, or to pursue his severer studies during the hour of meals: in both which cases, they, who adopt the custom, not only err in employing too continuous an application of the powers of the mind; but in impeding to a certain and often very inconvenient degree the process of natural respiration; and consequently, of other functions of the body, particularly of digestion. How main a point ought it to be therefore with those who superintend the education of young persons, to avoid the application of too great a strain on the natural spring of the intellectual powers.

It is questionable whether at any period of life the correspondence between the external world and the sensitive and intellectual faculties of man, is so rapid, so vivid, and so effectual, as during that space which is intermediate to infancy and adolescence: and this fact, if it be so, may be explained by that principle of our nature, on which depends the love of novelty; namely, that susceptibility of the nerves which makes them capable of being stimulated more vehemently by new, than by accustomed impressions: for certainly this principle is likely to be more exercised in proportion as we are nearer the period of infancy; since every impression is then either absolutely new, or has not yet rendered the nerves dull by too frequent a repetition of its application. Another happy instance of the harmony that exists between the nature of man and the external world, is the readiness and confidence with which at this early period of life the impressions of sense are received. Where all is new, and therefore equally matter of wonder, there is yet no room for doubt. Nature teaches the mind to receive everything without distrust, and to rely implicitly on those inlets to knowledge, the impressions of sense, which are destined to be its only guides in the first years of life. Scepticism is not the tendency of childhood: and perhaps it is with reference to the analogy between the eye of faith and the eye of sense at this early period of life, that our Saviour pronounces a blessing upon those who receive the evidences of our religion with the simplicity of little children.

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* Lord chief justice Hale; (see Boswell's Life of Johnson, vol. ii. p. 511. 4to. London, 1791;) not to mention living authorities.

CHAPTER III.

On the Powers of the human Hand, considered as a corporeal Organ.

At length however, having passed the preparatory discipline both of natural and of parental education, and having arrived at the maturity of his powers, man is fitted to exercise his empire over the external world.

But before we consider the character of the materials provided for the supply of his various wants, or for the exercise of his intellectual faculties, let us examine more closely than hitherto the condition of those corporeal organs, by the agency of which he is enabled to produce the results intended.

There can be no doubt that those organs are, if not exclusively, at least pre-eminently, the *brain* and the *hand:* of the latter of which, not only are the uses of the several parts and of the whole made practically manifest every moment of our lives; but its antecedent capabilities are so open to the investigating eye of reason, as to afford one of the readiest subjects of physical demonstration. And although, with respect to the brain, we not only have no satisfactory evidence, but cannot even form a probable conjecture, of the use or mode of action of any particular part; yet we cannot doubt that it is the instrument by which our intellectual powers hold communion with external nature. I shall dedicate therefore this and the following chapter to the consideration of the general history of these organs.

It would be an invasion of the province of others to give an anatomical description of the several constituent parts of the human hand: but in saying that its adaptation to the various purposes to which it is applicable is so open to the investigating eye of reason, as to afford one of the readiest subjects of physical demonstration, a tacit reference was made to that remarkable part of the writings of Galen, in which he expatiates upon the capabilities of this wonderful instrument: and that that extraordinary writer could hardly have selected a better subject, for the exercise of his powers in intellectual analysis, will be readily granted on a perusal of the following passages; provided they correctly represent the spirit of the original.

In that portion of his works which bears this title, "On the Use of the various Parts of the Body," after having defined what is to be understood by the term *part*, or *member*, as applied to an animal body, Galen proceeds in the following manner:* "But all these parts of the body were made for the use of the soul, that sentient and intelligent principle which animates the body, and of which the body is merely the organ; and on this account the component parts of animals differ according to the nature of this principle: for some animals are bold and fierce; others are timid and gentle: some are gregarious, and co-operate for their mutual sustenance and defence; others are solitary, and avoid the society of their fellows: but all have a form or body accommodated to their natural dispositions and habits. Thus the lion has powerful fangs and claws; the hare has swiftness of foot, but in other points is defenceless. And the fitness of this arrangement is obvious: for those weapons with which the lion is furnished are as appropriate to his nature, as they would be useless to the timid hare; whose safety, depending entirely on flight, requires that swiftness of foot for which she is so remarkable. But to man, the only animal that partakes of divine intelligence, the Creator has given, in lieu of every other natural weapon or organ of defence, that instrument, *the hand;* an instrument applicable to every art and occasion, as well of peace as of war. Man therefore wants not a hoof, or horn, or any other natural weapon; inasmuch as he is able with his hand to grasp a much more effective weapon, the sword or spear. Besides which, natural weapons can be employed only in close conflict; while some of the weapons employed by man, as javelins or arrows, are even more effectual at a distance. And, again, though man may be inferior to the lion in swiftness, yet by his dexterity and skill he breaks in to his use a still swifter animal, the horse; mounted on whose back he can escape from or pursue the lion, or attack him at every advantage. He is enabled moreover by means of this instrument to clothe himself with armour of various kinds, or to entrench himself within camps or fenced cities. Whereas were his hands encumbered with any natural armour, he would be unable to employ them for the fabrication of those instruments and means, which give him such a decided advantage over all the other animals of creation.

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* Lib. I. cap. 2.

"Nor have we yet enumerated the most important of those privileges which the hand imparts to man. With this he weaves the garment that protects him from the summer's heat, or winter's cold; with this he forms the various furniture of nets and snares, which give him dominion over the inhabitants as well of the water as of the air and earth; with his hand he constructs the lyre and lute, and the numerous instruments employed in the several arts of life; with the hand he erects altars and shrines to the immortal gods; and, lastly, by means of the same instrument he bequeaths to posterity, in writing, the intellectual treasures of his own divine imagination; and hence we, who are living at this day, are enabled to hold converse with Plato and Aristotle, and all the venerable sages of antiquity."

In reasoning on the utility of the hand, as characteristic of the human species, Galen thus expresses himself:* "Man being naturally destitute of corporeal weapons, as also of any instinctive art, has received a compensation, first in the gift of that peculiar instrument the hand; secondly in the gift of reason; by the employment of which two gifts he arms and protects his body in every mode, and adorns his mind with the knowledge of every art. For since, had he been furnished with any natural weapon, he would have possessed the use of this alone on all occasions; or had he been gifted with any instinctive art, he would never have attained to the exercise of other arts; hence he was created destitute of those insulated and individual means and arts, which characterise other animals; inasmuch as it is manifestly preferable to have the power of making use of various means and various arts. Rightly, therefore, has Aristotle defined the hand to be the instrument antecedent to, or productive of, all other instruments: and rightly might we, in imitation of Aristotle, define reason, as opposed to instinct, to be the art antecedent to, or productive of, all other arts. For as the hand, though itself no particular organ, is yet capable of being adapted to all other organs, and is consequently antecedent to them; so reason, though itself no particular art, is yet capable of comprehending and applying all; and may therefore be considered as an art antecedent to all others. Thus man alone, of all animals, possessing in his soul this general and original capacity, is justly endued in his body with this general and original instrument."

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* Lib. I. cap. 4.

"* Let us then scrutinize this member of our body; and inquire, not simply whether it be in itself useful for all the purposes of life, and adapted to an animal endued with the highest intelligence; but whether its entire structure be not such, that it could not be improved by any conceivable alteration.

"In the first place, it possesses in an eminent degree a leading quality of an organ of grasp; since it readily applies itself to, and securely holds, bodies of every form and size that are capable of being moved by human strength. Nor need we inquire whether it be better for this purpose that it should be divided into several parts; or, that it should be altogether undivided: for is it not apparent without further reasoning, that had it been undivided, it could have grasped only just such a portion of every object presented to it, as was equal to itself; but that, being divided into many parts, it can both easily grasp bodies much larger than itself; and can accurately search out, and lay hold of, the smallest particles of matter. For to the former it is capable of generally applying itself so, as to encompass them by the separation of the fingers; while in laying hold of very minute objects, the entire hand is not employed, but only the tips of two of the fingers: because from the grasp of the whole hand minute objects would easily escape.

"Thus then the hand is framed in the manner most convenient for laying a firm hold on objects both greater and less than itself. And in order to enable it to apply itself to objects of various shapes, it is evidently most convenient that it should be divided into many parts, as it is: and it seems to be better constituted for this purpose than any similar instrument; for it not only can apply itself to substances of a spherical form, so as to touch them with every part of itself; but it also can securely hold substances of a plane or of a concave surface; and, consequently, it can hold substances of any form.

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* Lib. i. cap. 5.

" And, because many bodies are of too great a size to be held by one hand alone, nature has therefore made each hand an assistant to its fellow; so that the two, when together laying hold of bodies of unusual bulk, on opposite sides, are fully equivalent to a single hand of the very largest dimensions: and, on this account, the hands are inclined towards, and in every point are made equal to, each other; which is at least desirable, if not necessary, in instruments intended to have a combined action.

" Take then any one of those unwieldly bodies, which a man can only lay hold of by means of both his hands, as a millstone or a rafter; or take one of the smallest objects, as a millet-seed or a hair, or a minute thorn; or, lastly, reflect on that vast multitude of objects of every possible size, intermediate to the greatest and the least of those above-mentioned; and you will find the hands so exactly capable of grasping each particular one, as if they had been expressly made for grasping that alone. Thus the smallest things of all we take up with the tips of the fingers; those which are a little larger we take up with the same fingers, but not with the tips of them; substances still larger we take up with three fingers, and so on with four, or with all five fingers, or even with the whole hand: all which we could not do, were not the hand divided, and divided precisely as it is. For suppose the thumb were not placed as it is, in opposition to the other four fingers, but that all the five were ranged in the same line; is it not evident that in this case their number would be useless? For in order to have a firm hold of anything, it is necessary either to grasp it all round, or at least to grasp it in two opposite points; neither of which would have been possible, if all the five fingers had been placed in the same plane: but the end is now fully attainable, simply in consequence of the position of the thumb; which is so placed, and has exactly such a degree of motion, as, by a slight inclination, to be easily made to co-operate with any one of the four fingers. And no one can doubt that nature purposely gave to the hands a form adapted to that mode of action, which they are observed to have;* while in the feet, where extent of surface is wanted for support, all the toes are arranged in the same plane. †But, to return to a point which we were just now considering, it is not merely necessary in laying hold of minute objects to employ the extremities of the fingers opposed to each other, but that those extremeties should be exactly of the character they are, namely soft, and round, and furnished with nails: for if the tips of the fingers were of bone, and not of flesh, we could not then lay hold of such minute bodies as thorns or hairs; or if they were of a softer and moister substance than flesh, neither then could such small bodies have been secured. For, in order that a body may be firmly held, it is necessary that it be in some degree infolded in the substance holding it; which condition could not have been fulfilled by a hard or bony material; and on the other hand, a material too soft would easily yield to substances of which it attempted to lay hold, and would continually let them escape: whereas the extremities of the fingers are just of that intermediate degree of consistence, which is calculated for their intended use.

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* Lib. ii. cap. 9.

† Lib. i. cap. 6.

"* But, since tangible substances vary much in their degree of hardness, nature has adapted the structure of the extremities of the fingers to that circumstance: for they are not formed either entirely of flesh, or of the substance called nail; but of a most convenient combination of the two: thus those parts which are capable of being mutually brought in apposition, and which are employed in feeling for minute objects, are fleshy; while the nails are placed externally, as a support to the former. For the fingers are capable of holding soft substances, simply by the fleshy or soft part of their extremity; but they could not hold hard substances without the assistance of nails; deprived of the support of which the flesh would be forced out of its position. And on the other hand, we could not lay hold of hard substances by means of the nails alone; for these being themselves hard, would easily slip from the contact of hard bodies.

"Thus then the soft flesh at the tips of the fingers compensating for the unyielding nature of the nails, and the nails giving support to the yielding softness of the flesh, the fingers are hereby rendered capable of holding substances that are both small and hard. And this will be more evident, if you consider the effect of an unusual length of the nails; for where the nails are immoderately long, and consequently come in contact with each other, they cannot lay hold of any minute object, as a small thorn or a hair: while on the other hand, if, from being unusually short, they do not reach to the extremities of the fingers, minute bodies are incapable of being held through defect of the requisite support: but if they reach exactly to the extremities of the fingers, they then, and then only, fulfil the intention for which they were made. The nails, however, are applicable to many other purposes besides those which have been mentioned; as in polishing and scraping, and in tearing and pealing off the skin of vegetables, or animals: and in short, in almost every art where nicety of execution is required, the nails are called into action."

In alluding to the sceptics of his time, the language of Galen is as follows. †"Whoever admires not the skill and contrivance of nature, must either be deficient in intellect, or must have some private motive, which withholds him from expressing his admiration. He must be deficient in intellect, if he do not perceive that the human hand possesses all those qualification swhich it is desirable it should possess; or if he think that it might have had a form and construction preferable to that which it has: or he must be prejudiced, by having imbibed some wretched opinions, consistently with which he could not allow that contrivance is observable in the works of nature."*

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* Lib. i. cap. 7.

† Lib. iii. cap. 10.

Galen then sums up this part of the argument. "The contrivances of nature are so various, and so consummately skilful, that the wisest of mankind, in endeavouring to search them out, have not yet been able to discover them all."† And nearly in the same words, expressive of the same sentiment, does Solomon say—"Then I beheld all the work of God, that a man cannot find out the work that is done under the sun: because though a man labour to seek it out, yet he shall not find it; yea farther; though a wise man think to know it, yet shall he not be able to find it."‡

I may be permitted, perhaps, to subjoin a passage from another part of the same work of Galen, though not confined to the same subject; in which, after having noticed many evidences of design in the construction of the human body, particularly the adaptation, in the number and size of the parts, to the effect to be produced, he breaks out into this remarkable apostrophe: ‖ "How can a man of any intelligence refer all this to chance, as its cause: or, if he deny this to be the effect of foresight and skill, I would ask, what is there that foresight and skill do effect? For surely where chance or fortune act, we see not this correspondence and regularity of parts. I am not very solicitous about terms; but if you choose to call that chance which has so nicely constructed and so justly distributed all the parts of an animal body, do so; only remember and allow, that in so doing you do not fairly exercise the privilege of framing new terms: for in this way you may call the meridian splendour of the sun by the name of night; and the sun itself, darkness. What! was it chance that made the skin give way so as to produce a mouth? or, if this happened by chance, did chance also place teeth and a tongue within that mouth? For, if so, why should there not be teeth and a tongue in the nostrils, or in the ear?" Or, to carry on a similar appeal, "did chance dispose the teeth themselves in their present order; which if it were any other than it is, what would be the consequence? If, for instance, the incisors and canine teeth had occupied the back part of the mouth, and the molar or grinding teeth had occupied the front, what use could we have made of either? Shall we then admire the skill of him who disposes a chorus of thirty-two men in just order; and can we deny the skill of the Creator, in disposing the same number of teeth in an order so convenient, so necessary even for our existence?"

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* Galen adds: "Such persons we are bound to pity, as being originally infatuated with respect to so main a point; while at the same time, it behoves us to proceed in the instruction of those happier individuals, who are not only possessed of a sound intellect, but of a love of truth."

On another occasion, in reprobating such cavillers, he says: (lib. iii. cap. 10.) "But if I waste more time on such profligates, virtuous men might justly accuse me of polluting this sacred argument, which I have composed as a sincere hymn to the praise and honour of the Creator; being persuaded that true piety to him consists, not in the sacrifice of whole hecatombs of oxen, nor in the offer of a thousand varieties of incense; but in believing within ourselves, and in declaring to others, how great he is in wisdom, power, and goodness."

† Lib. x. cap. 10. ‡ Eccles. viii. 17. ‖ Lib. xi. cap. 7. and 8.

He then extends the argument to the teeth of other animals, as corresponding with the nature of their food; and also to the form of their feet, as having a relation to the character of their teeth.

"Never," says Cuvier, one of the most experienced physiologists of the present age, "never do you see in nature the cloven hoof of the ox joined with the pointed fang of the lion; nor the sharp talons of the eagle accompanying the flattened beak of the swan."

In corresponding expressions Galen exclaims, "* How does it happen that the teeth and talons of the leopard and lion should be similar; as also the teeth and hoofs of the sheep and goat; that in animals which are by nature courageous, there should be found sharp and strong weapons, which are never found in those animals that are by nature timid: or, lastly, that in no animal do we meet with a combination of powerful talons with inoffensive teeth? How should this happen, but that they are all the work of a Creator, who ever kept in mind the use and mutual relation of different organs, and the final purpose of all his works?"

CHAPTER IV.

On the Brain, considered as the Organ of the Intellectual Faculties.

It can no more be doubted that many of the phenomena of nature, and the important practical and philosophical conclusions deduced from them, would have been hitherto concealed from human knowledge, had man failed to exercise those intellectual faculties with which the Creator has endued him; than that political communities would have failed to exist, and social life to be adorned with the arts of civilization, had all mankind determined to pursue the mode of life adopted by savage tribes: nor can it be doubted that the Creator, in imparting to man intellectual faculties superior to those of brutes, intended that he should exercise them, not solely with a view to the higher and future destination of his nature, but also with a view to the purposes of this present life.

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* Lib. xi. cap. 8. ed. Kühn. vol. iii. p. 875 lin. 3—17. and p. 892. lin. 12.—17.

Since however the senses of hearing, sight, and touch, which are the great inlets of knowledge, are possessed by many of the inferior classes of animals in common with ourselves, by some indeed in a more exquisite degree; since also those animals are capable of remembering past, and conjecturing future events, although incapable of the more abstract functions of the understanding; it becomes highly interesting to inquire whether there is anything in the physical structure of man which renders him more capable of being acted on by external agents, with respect to the developement of his intellectual faculties, than brutes are: in other words, whether there is a material instrument in animal organization, the general composition of which is in obvious correspondence with the degree of intellect evinced by different species of animals, including man as one of those species.

Now, if any one in the least degree conversant with the laws of optics and of sound, were to doubt the adaptation of the structure of the eye and of the ear to those laws respectively, he would fairly be ranked among the individuals of that class of speculatists whose minds are too weak to apprehend any truth. And though there is not so obvious a relation between the structure of the brain and the exercise of the mental faculties, as in the case of the eye and light, and of the ear and sound; yet the indications of a mutual connexion between the two are both clear and numerous. And hence not only have philosophical inquirers in all ages acknowledged such a connexion; but the most common observers have ever felt an intuitive conviction of its existence, and have considered the brain as the instrument of thought and reason:* the truth of which assertion is evident from various metaphorical terms expressive both of intellectual defect and of intellectual excellence.

It may be presumed that, without the aid afforded by the study of anatomy or natural history, the most cursory observer might discover that the indications of intelligence manifested by the various classes of animals generally correspond in degree with their approximation in physical structure to man; and that, if we confine our view to the four highest classes, namely fish, reptiles, birds, and quadrupeds, and consider them with reference to their respective degree of docility; fish and reptiles, which are the lowest in the scale, will readily be allowed to be inferior to birds, which are a degree

* . . . . and his pure brain
Which some suppose the soul's frail dwelling house
Doth, by the idle comments which it makes,
Foretell the ending of mortality.
King John, Act 5, Scene 7.

higher in the scale; and these again will with equal readiness be allowed to be inferior to quadrupeds, which are the highest.

And it would be acknowledged upon a more accurate investigation, that, although there are at first sight some seeming exceptions to the regularity of gradation, the apparent anomalies vanish when put to the test of a philosophical examination. Should it be said, for instance, that the bee or the ant shows greater indications of intelligence than many species much higher in the scale of animal creation, it may be answered that those indications are manifested in actions which are referable to instinct, rather than intelligence; actions namely, which being essential to the existence of the individuals, and the preservation of the species, are apparently determined by some internal impulse which animals unconsciously obey. Nor does it militate against such a notion of instinct, that when accidental impediments prevent the regular evolution of the comb, taking that as an instance, the bee accommodates the arrangement of its fabric to the impediment which is placed in its way: for such a modification of instinct is as clearly necessary in the case of an occasional impediment, as instinct itself is necessary for the general purpose.

In speaking of instinct I purposely avoid a formal definition of the term: for any attempt to define with accuracy a principle, of the real nature of which we are ignorant, usually leaves us in a state of greater darkness than we were before; of which the following extraordinary attempt, with reference to the very principle now under consideration, is a sufficient illustration. It is quoted from an author of the name of Wagner, in a work on the Brain of Man and other Animals, written by Wenzel and his brother; and is as follows: "The instincts of animals are nothing more than inert or passive attractions derived from the power of sensation: and the instinctive operations of animals nothing more than crystallizations produced through the agency of that power."*

Of the general position, then, that the brain is the instrument of intelligence, and that the degree of intelligence characteristic of different classes of animals is proportional to the approximation of their structure to that of man, it may for the present be presumed that no one doubts.

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* "Instinctus animalium nihil aliud sunt, quam attractiones mortuæ a sensibilitate profectæ; et eorum artificia nihil aliud quam crystallizationes per sensibilitatem productæ." Wenzel, De penitiori Structura Cerebri. Tubingæ, fol. 1812. p. 248, l. 10.

CHAPTER V.

THE NERVOUS SYSTEM OF ANIMALS IN GENERAL.

SECTION. I.

The Nervous System of the inferior Animals.

As the peculiarities in the structure of the human brain cannot be understood without a reference not only to the brain but to the nervous system at large of other animals; it will be necessary to take such a survey of that system as may be sufficient for the present purpose.

In the lowest species of animals, which appear to be devoid of any specific organs of digestion, motion, or sensation; whose economy indeed only enables them to contribute, in a mode as yet unknown, to the nutrition and preservation of the individual, or to the continuation of the species, no distinct nervous system has yet been discovered, or at least satisfactorily demonstrated: it is presumed rather than known that in such animals there exists a variable number of small insulated masses of nervous matter called *ganglions*, which are connected with each other, and with different parts of the body, by means of slender filaments that radiate from these masses in various directions.

In ascending the scale of animal existence we meet with species, in which, though devoid of organs of sense and motion, there exist distinct organs of digestion: and in such species the upper part of the passage leading from the mouth to the stomach is usually surrounded by a kind of collar, from whence distinct nerves are distributed to the other parts of the body.

In ascending still higher the scale of animal existence we find, together with a greater symmetry of structure in the whole individual, additional component parts of the nervous system, and a greater degree of regularity in the distribution of these supperadded parts. Thus in those classes of animals which include the leech, the centipede, and the bee, whose bodies are naturally divisible into distinct segments, we find a series of ganglions placed opposite the respective segments, and sending out nerves which are appropriated to the muscles of voluntary motion attached to these segments: and the several ganglions are reciprocally united by intervening portions of a nervous cord, which is continued from one extremity of the body to the other; so as to present the appearance of a thread in which knots have been tied at stated intervals. And in those species of these classes which have eyes, as is the case with insects, there are additional ganglions near the head; from which arise the nerves of vision, and probably, of touch.

If, in ascending still higher the scale of animal existence, we examine the nervous system of fish, reptiles, birds, and quadrupeds, we find that those parts which are subservient to the nutrition of the individual, and to the continuation of the species, are supplied with ganglions and nerves corresponding in their general character and mode of distribution with the nervous system of the lower classes: and that the arrangement of the nerves of voluntary motion merely differs from that of the intermediate classes, in being more elaborate; the individual nerves all communicating with a continuous cord which extends from one extremity of the body to the other; but which instead of floating loosely in the general cavity of the body, as in insects, &c. is contained in a canal essentially consisting of a series of parts called *vertebræ*, which taken together form what is called the spine or backbone. From the structure of this spine these classes are called *vertebrated:* and it is deserving of notice that these classes alone have a *cranium*, or skull.

The nervous cord above described is known more familiarly under the name of the spinal *marrow*, a term which is derived from its resemblance, in some of its physical characters, to the oil contained in the interior of the bones of man and various other animals.

That portion of the spinal cord which is contiguous to the head is continued into the cavity of the skull; and is there apparently lost in a more or less regular mass of nervous matter called the brain: which is small, and simple in its structure, in fish; larger, and more complicated, progressively, in reptiles, birds, and quadrupeds; largest, and most complicated, in man. From the lower surface of the brain arise several pairs of nerves which are principally distributed upon the organs of the distinct senses, and muscles of the face; and it is worthy of observation, that while the muscles of mere animal motion, as of the trunk and extremities, are derived from the spinal marrow; the muscles of the face, which may be called pre-eminently the muscles of moral and intellectual expression, are derived from the brain itself.

In ascending then from fish, the lowest of the four classes of vertebral animals, to quadrupeds which constitute the highest class, the general mass, of the brain upon the whole increases in proportional size; and at the same time it also more and more resembles that of man both in its general form, and in the character and proportions of its several parts. But the human brain, when fully developed, contains parts which do not exist in the brain of those animal species which approach nearest to man in the structure of this part.*

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* It may be convenient here to state that the human brain is naturally divisible into two parts, called the *cerebrum* and *cerebellum;* of which the former is eight or

It cannot be uninteresting in an inquiry like the present to add, with respect to those occasional deviations from the common form, called monsters and lusus naturæ, that nature never elevates the brain of an individual of a lower to that of a higher class; though the brain of an individual of a higher is frequently not developed beyond the degree of a lower: and this law of the developement of the brain is, with reference at least to the distinction of classes, correspondent with that of the general form. Thus a lusus naturæ or monster in the class of quadrupeds, for instance, or of birds, may have two heads, or eight legs; but the supernumerary parts will be always those of its own class, indeed of its own species; and therefore it is absurd to suppose that if there be no mixture of species in the same class, there should ever be a confusion of two distinct kingdoms of nature.

Horace, than whom no one better understood the principles of imaginative or artificial poetry, knew that abrupt combinations of heterogeneous subjects would certainly offend a correct taste, because unnatural: for taste, it may be affirmed, is, in one of its essential attributes, a feeling in harmony with natural combinations; whether the individual combination be that of sounds, or colours, or forms, or of intellectual images, or moral sentiments: and nature, which may be pre-eminently called the τέχνη ποιητικὴ, though she may occasionally surprise the mind by unusual combinations of organs natural to the species, never so couples together heterogeneous organs, as that the limbs of animals of one species should be united with those of another species; in short, as Horace himself expresses the conception,

> .... Non ut
> Serpentes avibus geminentur, tigribus agni.*

SECTION II.

The Nervous System of Man.

THE nervous system of man, without any reference to that of other animals, naturally resolves itself into three sufficiently distinct divisions: of which one is appropriated to those parts, which characterise him as simply an organized being; another, to his powers of voluntary motion; the third, or the brain, to the organs of the

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nine times larger than the latter. The cerebrum, which occupies nearly the whole of the cavity of the skull, consists of two parts, called *hemispheres*: and it should be particularly borne in mind that it is with reference to the great size of its hemispheres that the human brain exceeds that of all other animals.

* The subject of lusus naturæ, or monsters, will be resumed towards the conclusion of this treatise.

several senses, and, probably, to the manifestation of the intellectual powers and moral affections.

Of the two first of the foregoing divisions it is not necessary to speak more at large; because no doubt exists in the minds of physiologists as to the nature of their offices. But this is not the case with respect to the brain; which therefore demands a greater share of our attention.

Of all the parts of the nervous system taken collectively, the brain has been most generally considered as the organ of the mind: and it has long been a favourite speculation to endeavour to ascertain what part of this organ is subservient to the existence and exercise of those intellectual powers and moral feelings, which to a greater or less extent are possessed by many other animals as well as man. It is presumed at least that of the existence of intellectual powers or moral feelings in brutes no one can doubt, who has been at all accustomed to observe the characters and habits of animals;* so that when in common language it is asserted that man differs from other animals in possessing reason, while they are irrational, the term reason must be taken in its most extended sense, as implying the aggregate faculties of man, both moral and intellectual.

I will not here insist on the evidence of the intellectual powers of brutes, as deducible from the effects of what we call instinct; because in all those actions which are the result of instinct, animals appear to be guided by a natural and irresistible impulse from within, which leads them to seek or to avoid that which will be either useful or injurious to them; and enables them to perform the most complicated acts, as the building of a nest or the construction of a comb, though they may never even have seen the same acts performed by other individuals of their species. I would rather insist on that evidence of their intellectual powers, which is derived from their conduct, when, in consequence of having been removed from their natural sphere of action, they are impelled by external and accidental circumstances. Thus the wariness of old animals in avoiding the pursuit or arts of man, and the sagacity with which a practised hound will cut off an angle in order to shorten his distance, may be considered as proofs of a considerable degree of intellectual rather than of instinctive prudence in brutes.

The playfulness of the young of most quadrupeds, often indeed observable in the adult animal also, may be regarded as no obscure proof of the exercise of the intellectual faculty which we call imagination; for that playfulness almost always consists in the representation of mutual hostility, though the real disposition at the same time is anything but hostile. The dog for instance, under such circumstances, snarls and bites, but with evident intention not to hurt.

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* Aristotle, in his History of Animals, distinctly affirms such an existence—ἔνεστι γὰρ ἐν τοῖς πλείστοις καὶ τῶν ἄλλων ζῴων ἴχνη τῶν περὶ τὴν ψυχὴν τρόπων, ἅπερ ἐπὶ τῶν ἀνθρώπων ἔχει φανερωτέρας τὰς διαφοράς. p. 212. lin. 7—10. ed. Bekker.

Of the existence of moral feelings in brutes, there is still more decided proof than of the existence of intellect. Thus the expression of joy in a dog at sight of his master is not to be mistaken, and the expression of fear in a horse at the sound of the whip is equally unequivocal in its character. Again, animals become attached not only to individuals of their own species, but to individuals of even a different order or class: and they evidently feel regret upon separation from these their companions.

On the supposition that the brain is the organ of the intellectual powers, physiologists have been led to compare the proportions of the whole and of its several regions in man and brutes; in order to arrive at a knowledge of such facts as might serve for a basis for ascertaining which are the parts essential to its action as such an organ. It has been supposed by some that the intellectual faculties may be in proportion to the *absolute* size of the brain; such an opinion being grounded on the fact, that the human brain is larger than that of the horse or ox. But on the other hand, the brain of the whale or of the elephant taken in its whole mass is larger than that of man; though the intelligence even of the elephant bears no proportion to that of the human mind. Again, the brain of the monkey or of the dog is smaller than that of the ox or the ass; yet with respect to their intellectual faculties the former approximate much more closely to man than the latter. Neither do the dispositions or qualities of animals appear to be connected with the absolute size of their brain: for animals most different and even opposite in disposition may be ranged in the same class with reference to the size of this organ; the tiger and the deer, for instance, among quadrupeds; and among birds, the hawk and the pigeon.

It would appear probable from some instances, that the *proportional* size of the brain with reference to the size of the body would give a more uniform result. Thus a crocodile twelve feet in length, a serpent eighteen feet in length, and a turtle that weighs from three hundred to five hundred pounds, have not any of them a quantity of substance in their brain equal to half an ounce; and the slight degree of intellectual power manifested by these animals corresponds with such a proportion. But on examination it appears that the proportional size of the brain is not a more certain criterion than the absolute size. The brain of the elephant for instance is smaller in proportion to its body than that of any other quadruped: and yet what quadruped exceeds the elephant in sagacity? and, in comparing many of the inferior animals with man in this respect, it is found that not only do different genera of the same order differ very widely from each other in the proportion of their brain to their body, as the bat and the fox; but that the proportion is sometimes inversely as the degree of intellect of the animal: thus, as far as we are capable of judging, the intellect of the fox is infinitely greater than that of the bat, and yet the brain of the former, proportionally to its body, is only one half the size of the latter. Occasionally the disproportion is still greater in different species of the same genus, and even in different varieties of the same species: thus in some dogs the brain compared with the body is as one to fifty, while in others it is as one to three hundred.

Again, it appears that the brain of some of the genera of the lowest orders in a class is proportionally larger than that of some of the genera of the higest orders. Thus, in the mammalia, the brain of the dolphin, which animal is in the lowest order of that class, is in proportion to its body four times as large as the brain of the fox, which is an animal of one of the highest orders. And the brain of the mouse and of the mole are nearly, if not quite as large, in proportion to their body, as that of man. And the same circumstance occurs even in the second class, or birds; for the brain of the sparrow is in proportion to the body, as large as, nay even larger, than that of man.

Lastly, for it is unnecessary, and would be tedious, to enter further into the detail of this part of the subject, there does not appear to be any connexion between the degree of intellectual faculties and the mutual proportions of the several constituent parts of the brain; or between the degree of intellectual faculties and the mutual proportions of the brain and nerves. So that it appears, from a review of what has been advanced, that no criterion of the degree of intellect is found in the absolute size of the brain; nor in its relative size, as compared with that of the body of the individual; nor in the relative size of its constituent parts, or of the whole of it, to the nerves.

Section III.

Indications of natural Talent and Disposition deducible from the Structure of the Brain.

If the entire history of the brain were a primary object in this treatise, it would be right here to investigate in detail the observations and theory of Dr. Gall respecting this organ: but on the present occasion it will be unnecessary to refer to that theory further than may be required by the course of the argument.

The simple enunciation of Dr. Gall's theory is this, that "the brain in general is the instrument by which the intellectual faculties, and the moral sentiments and propensities, are manifested; particular parts of it being the organs of those several faculties, sentiments, and propensities: and that according to the state of these organs will be the faculties, sentiments, and propensities of each individual."

To those who have objected to this theory, that it leads towards the doctrines of fatalism, and the material nature of the soul, it has been answered; first, that as, according to the theory, no individual, who is endued with intellect, is deficient in the organs of those moral sentiments, which, if cultivated, will be sufficient to counteract whatever bad propensities he may have, the theory cannot consistently be accused of inculcating the doctrine of fatalism: and secondly, that without inquiring what the soul is, or in what manner it is united to the body in this life, which Dr. Gall considers as questions not only beyond the comprehension of human reason, but totally unconnected with his inquiries, the theory merely investigates the *material* conditions of that part of the body by which the soul is affirmed to manifest itself to our observation.

It has been already stated that, in exposing to view the lower surface of the brain, several pairs of nerves are observable which may be traced to the organs of sense and some other parts: and it is admitted by many anatomists of acknowledged accuracy, that, of all these pairs, not one, excepting the olfactory and optic, is derived from the great mass of the brain called its hemispheres: but Dr. Gall shows it to be highly probable in fact, as it evidently is in reasoning, that neither the olfactory nor the optic nerves are derived from the hemispheres: whence it would appear that, with the doubtful exception of the nerves of smell and sight, not a single nerve of the whole body is derived from the great mass of the brain: for the organs of the other senses, and all the muscles of voluntary motion, together with the whole assemblage of the organs of digestion, and the heart, and the lungs, are evidently supplied from other sources.

Either then the great mass of the brain is allotted in a most anomalous disproportion to the two senses of smell and sight, which in many animals are comparatively weak; or, if it do not supply the nerves of sight and smell, there is no part of the body which it does apparently supply with nerves: and then the conclusion presses upon us with peculiar force, that the brain is exclusively the instrument of the immaterial part of our present existence.

It appears from Dr. Gall's own account, that he was originally led to this peculiar train of thought by observing the difference of talents and character in his own brothers, and in other children with whom he happened to associate; some of whom, though under perfectly similar circumstances of education with the rest, were much quicker in apprehending what was taught them: and further, by observing in different individuals of the same species of animals, as dogs, that some were fierce, some mild: again, that in birds of the same species some continued to sing their own notes only, while others would listen to, and imitate, artificial music: and with reference to the last-mentioned instance particularly, he argued that the difference could not arise from the greater or less degree of perfection in the organ of hearing, for it is the same in both; but must be looked for in the brain, to which the organ of hearing conveys sounds; and in which, and not in the ear itself, they are perceived. There are moreover numerous instances which show that the sense of hearing is by no means in proportion to the degree of perfection in the construction of the ear. Thus, the dog, hears with indifference the sweetest melody: and yet the construction of his ear approximates more to that of man than the construction of the ear of even the most musical birds. And on this point Dr. Gall asks, if the organ of hearing determine the power of singing, why should the female bird be mute, seeing that in this part of its bodily construction it differs not from the male? It is equally observable that in men the talent for music is not in proportion to any superiority in the organ of hearing; in the construction of which indeed there is little if any apparent difference between any two individuals.

Partial insanity and partial idiotcy are among the circumstances which Dr. Gall considers as favouring his theory. The frequency of the former must be a fact well known to all: the latter is not uncommon; and even persons of considerable intelligence occasionally exhibit very obscure traces of this or that particular faculty. Other arguments in favour of his system he draws from the temporary effects produced by cerebral inflammation on the state of the mental powers: in the case, for instance, of idiots, who during the inflammatory action have manifested a considerable degree of understanding; but after the cessation of that action have relapsed into their former state of fatuity.

It would seem, in the instances here adduced by Dr. Gall, that the mental faculties which had been previously in a state of fatuity, are rendered for the time rational, in consequence of a degree of excitement which in individuals not labouring under fatuity would have probably produced delirium: and, as a rational state of the faculties may be considered, to use a mathematical expression, as a mean proportional to fatuity and delirium, it might be expected that the same cause which would raise a rational state of the faculties to delirium, would raise an idiotic only to a natural state: as, in a similar manner, wine is observed to modify the characters of individuals of different temperaments, by elevating them for the moment:

> "It keeps the unhappy from sinking,
> And makes e'en the valiant more brave."

It would occupy too much time to enter into the detail of this interesting part of Dr. Gall's system: nor was more originally intended than to introduce the subject to the consideration of those, who happen not to have reflected on it before, in such a manner as to enable them to form some judgment of the merits of a theory, the character of which has been injured to the full as much by its injudicious friends as by its professed enemies. Of this theory it may perhaps be affirmed with truth, that, considered as an abstract philosophical speculation, it is highly ingenious, and founded upon unobjectionable principles: and that while the general conclusion is inevitable with respect to the collective functions of the brain, there is nothing unreasonable in supposing that specific parts serve specific purposes. The rock, on which Dr. Gall and his implicit advocates have split, is the attempt to fix the local boundaries of the several faculties of the soul. Had he satisfied himself with developing the structure of the brain in the various classes of animals; and had he been content to show that, in tracing its structure from those animals which manifest the least indications of intelligence to those which exhibit still stronger and stronger, it proportionally advances in its resemblance to the structure of the human; and lastly, had he only drawn from these premises the general probable conclusion, that specific parts had specific uses with respect to the manifestations of the immaterial principle of animal existence: (and assuredly brutes are endued with such a principle, though, as being devoid of the moral sense, they are not fitted for a future state, and consequently perish when their bodies die;) had Dr. Gall been content to have stopped at this point, without venturing to define the local habitations of the supposed specific organs, he would have acquired the unalloyed fame of having developed a beautiful train of inductive reasoning in one of the most interesting provinces of speculative philosophy: whereas, in the extent to which he has carried his principles, his doctrine has become ridiculous as a system; while in its individual applications it is not only useless, but of a positively mischievous tendency: for, without the aid of this system, every man of common sense has sufficient grounds on which to judge of the characters of those with whom he associates; and it is evidently more safe to judge of others by their words and actions, and the general tenor of their conduct, than to run the risk of condemning an individual from the indication of some organ, the activity of which, for a moment allowing its existence, may have been subdued by the operation of moral or religious motives.

But there is an occasional absurdity in the application of the theory, which, though obvious, does not seem to have been noticed. Let us suppose, for instance, the case of a *murderer;* and that a disciple of Dr. Gall were to maintain that, as the crime of murder proceeds from the operation of the organ of destructiveness, that organ would be found highly developed in such an individual; and yet, upon actual inspection, this were not found to be the case. Here, although the disciple of Dr. Gall might be disappointed in finding no such developement, a plain reasoner would not be so disappointed: for is it not obvious that *avarice*, or *shame*, or *jealousy* might in a moment operate so powerfully as to lead an individual to the crime of murder, whose nature and habits were as far as possible removed from the propensity to that crime; and who, consequently, according to Dr. Gall's own principles, would be devoid of any undue developement of the organ of murder?

With respect to ourselves indeed, the study of the system may be attended sometimes with the happiest consequences: for if, from the contemplation of it, we can be strengthened in our conviction of the fact, which both reason and revelation teach us, that each individual is liable to particular temptations depending on his specific temperament, we shall thus have one additional memento of our frailty, one additional incentive to watch over, and combat, "the sin which doth so easily beset us."

Section IV.

The general Doctrine of Physiognomy, as connected with the Form of the Body.

As the indiscreet zeal, not only of Dr. Gall, but of physiognomists in general, has thrown unmerited discredit on that department of speculative philosophy which they have cultivated, it may be worth while to examine the subject on other authority than that of professed physiognomists.

There are many phenomena, then, connected with the moral and intellectual faculties of man, both in a healthy and diseased state, which, by showing the reciprocal influence of the two distinct parts of our nature, the soul and the body, render it probable that the energies of the former, although it be itself immaterial, may be manifested by means of a material instrument. The existence of this reciprocal influence, which indeed we might expect from their intimate though mysterious union, cannot be denied. Thus grief or expectation destroys appetite; and mental application to any favourite pursuit makes us insensible of the want of food: and, on the other hand, a disordered state of the digestive organs evidently impedes the free exercise of the mental powers; or oppresses the soul with those dreadful, though really groundless apprehensions, which have been termed *hypochondriacal* from the situation of the organs, the morbid state of which is supposed to give rise to those apprehensions. Again, intoxication confuses the memory and judgment; and the repeated abuse of wine permanently debilitates the mind, and often terminates in confirmed insanity. The state of the air affects the mental energies and moral feelings of many individuals, to a degree inconceivable to those who are not thus subject to its influence. And the impression of fear has been known suddenly to arrest the symptoms of endemic ague and epilepsy.

The general idea that this connexion of the soul and body may be traced in the conformation of the latter, it will be at once remembered, is by no means new: and the anecdote of the unfavourable judgment passed on the moral disposition of Socrates, from the character of his countenance, will readily recur to the mind on this occasion. Aristotle has even entered into some details on the forms and shades of colour of the hair and features, and indeed of various other parts of the body, as indicative of particular temperaments or constitutions of the mind.* And it is hardly a question, whether every individual is not accustomed in some degree to decide on character from the features, the colour of the hair, and other external indications, indedendently of that expression of the countenance, which rather marks the actually existing state of the mind than the latent disposition of it.† But if it be in any degree probable that the connexion between the soul and body may be traced in the conformation of the features or other parts of the body, in a much greater must it be probable that that connexion may be traced in the structure of the brain.

Nor does there appear, on the ground either of reason or of religion, any thing objectionable or absurd in the assumption, antecedently to observation, that the intellectual and moral tendencies of the soul may in a qualified sense be determined, or at least modified, by the peculiar structure of the body: that they are frequently coincident with certain peculiarities of corporeal structure is a matter of actual observation.

Is it absurd to suppose that, man being a compound of soul and body, the body has been so constructed in each individual as to become a fit arena on which that struggle shall be manifested, which undoubtedly takes place between the conflicting passions of the soul? For it will not be denied by those to whom this treatise is addressed, that the soul wants not the substance of a corporeal frame for the mere existence of its evil principles, but only for the external manifestation of them. An authority at least which cannot be questioned by a believer in revelation, asserts that out of the heart, that is, evidently from the context, out of the soul, proceed murder, theft, adultery, and the like.

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* For an exposition of Aristotle's views on this subject, consult a work of Galen, entitled ΠΕΡΙ ΤΩΝ ΤΗΣ ΨΥΧΗΣ ΗΘΩΝ, in which the question of the connexion between the faculties of the soul and the conformation of the body is discussed. Galen. op. Kühn. vol. iv. p. 768—798.

† Shakspeare has several references to indications of personal character, as depending on the form of the countenance, &c.

Cleopat. Bear'st thou her face in mind? i'st long, or round?
Messeng. *Round*, even to *faultiness*,
Cleopat. For the most part too,
They are *foolish* that are *so*. Her hair, what colour?
Messeng. Brown, madam: and her *forehead*
As *low* as she would wish it.
ANTONY AND CLEOPATRA, Act III. Scene 3.

Caliban. . . . . We shall lose our time,
And all be turn'd to barnacles, or to *apes*
With *foreheads villanous low*.
TEMPEST, Act IV. near the end.

Julia. Ay, but *her forehead's low; and mine's as high.*
TWO GENTLEMEN OF VERONA, end of Act IV.

Is it absurd to suppose that, the brain being a very complicated organ, made up of distinctly different parts, these parts are subservient to the exercise of different functions? or, since it is evident that in every other individual organ of the body, where there is an identity of structure, there is also an identity of function in all the parts, may we not fairly presume that, were the integral parts different, the effects produced would be different; and, consequently, that as the integral parts of the brain differ from each other, the offices of those parts may be different? Or, again, will it be denied as a matter of fact that different faculties and propensities manifest themselves in different individuals; and is it unreasonable, on the ground of analogy, our only ground in this case, to suppose that they manifest themselves through the agency of different instruments? And since the visceral nerves are appropriated to the mere vital functions of nutrition; and the spinal nerves to general muscular motion and common sensation; and the nerves of the special senses occupy but a very small portion of the brain; to what assignable purpose can the great mass of that organ be applied, if not to the operations of that intellectual and moral principle, which, after the abstraction of the organs of nutrition, motion, and sensation, is the only imaginable part of our present nature?

Is the language of Scripture entirely allegorical throughout the sacred volume? or do we believe on just grounds that we are contaminated with an innate propensity to evil; that there are two principles within us constantly struggling for the mastery; and that, spite of our better part, and against the strongest feelings of conscience and determination of judgment, we still are for ever yielding to the worse?

Shall we deny that the tendencies to evil are different in character in different individuals; and by that denial shall we attempt to falsify the testimony of experience as to the fact itself; and the conclusions of antecedent reasoning as to its probability: for, if all men were avaricious for instance, or ambitious in the same points, where would be the field for the display of other qualities; and how could the affairs of the world be conducted?

But whatever may be the real state of the case—whether the brain act as a simple organ by the simultaneous operation of all its parts; or whether those parts act independently in the production of specific effects—no one can doubt that the organ itself is the mysterious instrument by means of which, principally, if not exclusively, a communication is maintained between the external world and the soul. Nor can it be doubted, indeed it is a matter of fact which is constantly open to our observation, that the degree of approximation in the structure of the brain of other animals to that of man bears a very obvious relation to the degree of intelligence manifested by the various classes of animals: so that, in just reasoning, it must on every consideration be admitted to be the instrument by which the various degrees of intelligence are manifested.

It is a matter also of observation, that the powers of the mind are capable, like those of the body, of being strengthened by exercise and cultivation: and, further, that not only do the mental faculties gradually manifest themselves from the moment of birth onwards; but that the physical developement of the brain advances proportionally up to a certain period. But on this point it will be desirable to make a few more particular remarks.

Section V.

The Developement of the Human Brain, compared with that of other Animals.

The brain of all vertebral animals, including even man, is nearly identical in structure in the early period of the embryo state of those animals. But at the period of birth there is a very remarkable difference between the degree of developement of the human brain, and of that of the inferior animals. In quadrupeds for instance, the brain, according to Wenzel, is fully developed at the moment of the birth of the individual; contains, that is, at that time, all the parts in as perfect a state as they are in the adult animal of the same species (Wenzel, p. 246): while, with respect to the human species, it is asserted by Wenzel, and his statement is confirmed by the observations of others, that although the brain makes continual and rapid advances to its ultimate magnitude and perfect state, from the period of conception to the seventh year after birth, yet all the parts have not attained their full size till the age of seven years (p. 254). And this difference is exactly what might be antecedently expected, from the comparatively greater degree of intelligence manifested by the young of other animals, of the higher orders at least, than by the human infant.

But it is very worthy of observation, that those parts of the human brain, which are formed subsequently to birth, are entirely wanting in all other animals, including even quadrupeds, which Wenzel has examined (p. 246): and that during the evolution of the parts peculiar to the human brain, the peculiar faculties of the human intellect are proportionally developed: and finally, that, till those parts are developed, those faculties are not clearly perceptible (Wenzel, p. 247). But at the age of seven years the human being essentially possesses, although not yet matured by exercise and education, all those intellectual faculties which are thenceforward observable: and at that age the brain is perfect in all its parts. And, from the age of seven years to the age of eighty, the changes of the human brain with respect to size, either collectively or in its several parts, are so trifling as hardly to be worth notice (p. 247—266).

In comparing either individual actions or the complicated operations of man, with those of other animals, it is observable, that the actions and operations of the adult human being as much excel in design and method the actions and operations of all other adult animals, as those of the infant are excelled in precision and adroitness by the young of all other animals (p. 247): and both these facts correspond with the relative constitution of the brain at the respective periods; the brain of other animals being perfect at birth, which is not the case with the infant; while the brain of the adult human being manifests a higher degree of organization than that of any other animal, and is therefore physically fitted for functions of a higher order.

It appears then highly probable, both from the intuitive conviction of mankind at large, and from a comparative examination of the structure and developement of the brain in man and other animals, that the intellectual superiority of man, physically considered, depends on the peculiarities of the human brain: and with respect to the rest of his body, it is certain that the hand is the instrument which gives him that decidedly physical superiority which he possesses over all other animals. In all other respects there is no physiological difference, of any importance at least to the present argument, between man and the higher orders of animals: and the pecuculiarities of his physical condition, with reference to the form and general powers of his body, rest therefore on those two organs, the *hand* and the *brain*. And as the adaptation of the external world to the physical condition of man must have a special reference to those peculiarities in his structure which distinguish him essentially from other animals, it has therefore been thought important to dedicate a considerable portion of this treatise to the investigation of the characters of the two organs above-mentioned.

Section VI.

Cursory View of the Extent of Human Power over the Objects of the External World.

Having examined, as far as is necessary for the purpose of this treatise, the animal character of man, both with respect to the points in which he partakes of the nature of other species, and those in which he is elevated above them; let us proceed to consider the adaptation of the external world to the physical condition of that being to whom the Creator has given dominion over all his other works; whom alone, of all the living tenants of the earth, he has endued with a mind capable of conceiving, and corporeal powers capable of executing those wonderful combinations, which make him lord of the world which he inhabits; which enable him to compel the properties of inert matter to bend to his behests; and to direct not only the energies of the inferior animals, but even those of his fellow creatures, to the purposes which he may have in view.

In contemplating, for instance, as in all the pride of its appointments it advances through the waves, the majestic movements of a man-of-war, let us trace its whole history, and thence admire the extent of human power over the material world. Look at the rude canoe of the New Zealander, or call to mind the nearly as rude coracle of our own forefathers, and compare those simple and puny products of an infant art with the complicated and gigantic triumph of naval architecture now before you; and no wonder if, observing the ease and precision of its movements, the unlettered savages of the islands of the Pacific conceived the stupendous machine to be some form of animated matter; whose fierce nature and awful power were announced by the tremendous roar and destructive effects of artillery.

Or, passing from inert matter to living and intellectual agents, let us in imagination first view the tumultuary and predatory incursions of the aboriginal borderers of the Ohio, or even of the more civilized tribes of modern Arabia; revenge or booty their sole objects, without any plan of civil government or national aggrandizement; and then let us contemplate the profound views and combinations of the Macedonian monarch—that military meteor, whose course, though occasionally eccentric, was yet constantly regulated by the preponderating attraction of his original design; and whose plans, though marked by temporary and local devastation, yet secured the foundation of the durable and general prosperity of future generations. The theme is too vast and too sublime for the present effort, even had it never been before attempted; but the genius of the learned author of the "Commerce and Navigation of the Ancients"* has admirably developed the great and profound views of Alexander, ignorantly described by Pope as the reveries of insane ambition; and has significantly alluded to the successful accomplishment of his wonderful attempt, in that beautifully appropriate legend placed under the engraving of the head of his hero,

> "Aperiam terras gentibus."†

Or let us investigate the career of the equally extraordinary conqueror of the present century. View him overcoming every moral and physical difficulty in the pursuit of his gigantic and fearful project of universal empire; uniting distant and hostile nations in confederacies against their own liberties; changing their long established dynasties, in order to set over them kings of his own family. View him absorbed in his heartless calculations on the advantages to be obtained, for his personal aggrandizement, by the endless sacrifice of human life; breaking into the peaceful occupations of domestic scenes, and desolating the happiness of myriads of his subjects, not to ward off the dangers of hostile invasion, nor to lay the foundation of the future good of his country, but solely to gratify his own insatiable thirst of power; and yet by the magic of his name rallying round his standard, even to the last, the remnants of his former reckless schemes of inordinate ambition.

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* The very reverend W. Vincent, D. D. late dean of Westminster.

† Q. Curt. lib. ix. cap. 6.

In meditating on the astonishing scene presented to the imagination by the description of a career so strange, we might almost be in doubt whether these effects were produced by a mere human mind; or marked the presence of a superhuman intelligence, permitted for a time to exercise a guilty world. But whatever he were, he is gone; and his place will know him no more. One moral reflection in the meantime forces itself upon the mind; partly applicable to himself, and partly to mankind at large.

Inebriated with prosperity, and regardless of the power which could alone uphold him, he fell from his towering height; and was banished far from the theatre of his former ambition, and almost, indeed, from the haunts of men. But, haply, the prolongation of his life in the silent retirement of that sequestered island was mercifully intended to lead him to a calm reflection on the real value of sublunary possessions: for how very visionary and like a dream must all his former life have frequently appeared to him, when standing on the brow of some precipitous rock, the natural boundary of his insulated prison, he mused on the interminable expanse of the Atlantic; and compared his present desolation with his former glory. Or, if the terrors of Omnipotence failed even then to reach his obdurate heart, his example at least remains a merciful beacon to others; who may learn from his doom, that there is a Power which can say, as easily to the tempestuous ocean of ambition, as to the deep, " Hitherto shalt thou come, but no further: and here shall thy proud waves be stayed."

CHAPTER VI.

ADAPTATION OF THE ATMOSPHERE TO THE WANTS OF MAN.

Section I.

The general Constitution of the Atmosphere.

In the foregoing part of this treatise the physical condition of man has been considered under the view of the capabilities of his nature, rather than of his actual state: but it is evident on a moment's reflection that his actual state will be very different at different periods of time, or in different parts of the world at the same period: and this observation applies no less to communities than to individuals. How great the contrast, with reference to the case of individuals, between the intellectual powers and attainments of a Newton and a native of New Holland; and in the case of communities, how great the contrast between any of the kingdoms of modern Europe, and the rude tribes from whence they were originally derived.

In proceeding then to illustrate the adaptation of the external world to the physical condition of the human species, we must view individuals or communities under all possible circumstances of existence, and make the illustration of as general application as the nature of the subject evidently demands.

And, in order to effect something like a systematic arrangement of the immense mass of materials whence the following illustration is to be deduced, it is proposed to investigate separately the four kingdoms or divisions of nature, the general characters of which were given in the commencement of this treatise; beginning with the atmospherical and ending with the animal kingdom.

If it were possible, with the bodily as with the mental eye, to behold the constitution of the atmosphere which surrounds our earth, we should view a compound probably the most complex in nature: for into this circumambient ocean of air, as it is called by Lucretius,* are carried up whatever exhalations arise not only from the earth itself, but from every organized form of matter whether living or in a state of decomposition that is found upon the earth's surface; the dews of morning, the balms of evening, the fragrance of every plant and flower; the breath and characteristic odour of every animal; the vapour invisibly arising from the surface of the whole ocean and its tributary streams; and, lastly, those circumscribed and baneful effluvia, however generated, which when confined to definite portions of the atmosphere produce those various forms of fever which infest particular districts: or those more awful and mysterious miasmata, which, arising in some distant region, and advancing by a slow but certain march, carry terror and death to the inhabitants of another hemisphere.

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* Semper enim quodcunque fluit de rebus; id omne
Aëris in magnum fertur mare. Lib. V. 277, 8.

Such is the complex character of the atmosphere; and, indeed, from this assemblage of vapours contained in it, it has received its peculiar appellation; being the receptacle, or magazine, as it were, of terrestrial exhalations.[*]

All these various exhalations however may be considered as foreign to the constitution of the air, being neither constantly nor necessarily present anywhere; all, with the exception of that aqueous vapour which is continually arising from the surface of the earth, as well as of the ocean and every lake and river. But, in addition to this aqueous vapour, the air is also charged to a variable extent with light and heat and electricity: of which the two first are so obvioulsy adapted to the wants of man as to demand immediate attention. Electricity is probably of equal importance in its relation to man: but the true character of that relation has not yet been sufficiently developed to call for a distinct consideration on the present occasion.

SECTION II.

Light.

THE metaphorical expressions of all ages and nations, with respect to light, sufficiently evince the value in which that inestimable gift is held. In the sacred Scriptures indeed, not only are temporal blessings compared with light, and temporal evils to darkness; but holy deeds are frequently described under the character of the former; and unholy deeds under the character of the latter: and, with respect either to classical or oriental literature, a thousand instances might easily be adduced illustrative of the same metaphorical use of the terms in question.

When, after a dark and tempestuous night, the mariner first perceives the dawn of returning day; although that dawn discover to his view the evil plight to which the storm has reduced his vessel, why does he still hail day's harbinger as his greatest relief, but because without the aid of light he could not possibly extricate himself from the difficulties of his situation? Or, when the child, awakened from its sleep, finds itself alone in darkness, why is it overwhelmed with terror, and why does it call out for protection, but from the influence of those undefined fears, which naturally occur to the mind under the privation of light?

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[*] Ἁτμων σφαῖρα.

There is something so congenial to our nature in light, something so repulsive in darkness, that, probably on this ground alone, the very aspect of inanimate things is instinctively either grateful or the reverse, in consequence of our being reminded by that aspect of the one or of the other: so that on this principle, perhaps, particular colours throughout every province of nature are more or less acceptable in proportion as they approach nearest or recede farthest from the character of light, whether reflected immediately from the heavenly bodies, or from the azure of the sky, or from the thousand brilliant hues with which the setting or the rising of the sun illuminates its attendant clouds.

In illustration of the principle just advanced, gold and silver among metals might be opposed to lead and iron: and, among flowers, the brilliancy of the crocus, the lily, or the rose, to the lurid aspect of henbane or belladonna. And though something of a moral character may in these instances determine the preference; yet there is nothing unreasonable in supposing, that, as the instincts of the inferior animals regulate their tastes and distastes to natural objects; so there may also be in the case of human beings congruities, or the reverse, between the sense impressed and the object impressing it. In fact, with respect to that sense, the organ of which is the ear, it is known that infants shrink back from deep sounds, and express delight at acute sounds, long before any intellectual or moral feeling can sway them; and, correspondently with this assertion, the lullaby of the nurse partakes, among all nations, of the same essential character. It is a fact equally deducible from observation, that particular flavours and odours are naturally acceptable, or the reverse, to children. And again, with reference to the sense of touch, smooth surfaces almost universally give a pleasing impression; which is not imparted by rugged surfaces. Why then may it not be the same with respect to the sense of sight, in the case either of colour or of form?

The abundant supply of light from its natural source the sun, and the ease with which it is producible by artificial means during the absence of that luminary, render us habitually less sensible of its real value, than undoubtedly we should be, were we to experience a long continued privation of it. And as to the regularly periodical privation of it which we experience in consequence of the alternation of night with day, this is so far from being an evil, that it is obviously beneficial; inasmuch as, in consequence of this very absence, sleep is both directly and indirectly conciliated: without which gift of Heaven, all our faculties would soon be exhausted, and all our happiness consequently extinguished.

The beneficial influence of sleep on our whole frame is too obvious in its effects to require any formal demonstration: but it will be interesting to consider its relation to the absence of light. It appears then that, by a fundamental law of our nature, a sense of uneasiness invariably follows a long continued exercise of our powers, either corporeal or mental: and, unless this sense of uneasiness have been produced by too inordinate exercise, it is soon relieved by that state of the system which we call sleep; during the continuance of which, provided it be sound and of a perfectly healthy character, all the voluntary muscles of the body become relaxed, and the nervous system remains comparatively inactive; the whole body acquiring by this temporary cessation of its energies a renovated accumulation of those powers, which are necessary for the purposes of active and intellectual life.

In order to dispose us to yield to the sensation of approaching sleep, the periodical succession of night to day has been ordained by nature. For, with the approach of darkness cease all the usual stimuli of that sense, which is accommodated to the impulse of light, and which calls our faculties into action more frequently than any other: nor is the intention of nature less evident, because, either from avarice or the dissipation of luxury, some individuals protract the labours or the pleasures of the day beyond the natural period assigned for those purposes; since these are unnatural exceptions to the observance of the general law.

Although it would be difficult to prove directly that there is any necessary connexion between darkness and sleep, yet this connexion is rendered at least highly probable by the effect usually produced on the approach of darkness upon animals in general, but more remarkably on birds; for, with the exception of those whose habits are nocturnal, all birds betake themselves to sleep as soon as night approaches: and if darkness should anticipate night by many hours, as happens when any considerable eclipse of the sun takes place in the middle of the day, we still find the birds of the field as well as our domesticated fowls give the same indications of composing themselves to sleep, as at the regular period of sunset. If it should be said that this does not more serve to prove a connexion between darkness and sleep with reference to these animals, than to prove the effect of a long continued association resulting from their habit of going to roost at sunset; it may be asked, why should darkness, unless from some inherent cause, lead them to compose themselves to sleep at the hour of noon, instead of the usual hour of evening; since, on the one hand, periodical states of the animal system do not usually recur before the termination of the habitual period; and, on the other hand, the individuals cannot at so early an hour have experienced such a degree of exhaustion as would of itself invite to sleep?

In stating that the voluntary action of the muscles ceases during sound sleep, we ought not to omit the remarkable fact that those muscles which are not under the empire of the will continue their action uninterruptedly through the deepest sleep. Of all the muscles of involuntary motion, this observation holds most remarkably with respect to the heart; the continued action of which organ during sleep is a phenomenon worthy of the deepest attention of a philosophical mind. All other organs of the body have their periods either of absolute or comparative rest; the senses are in a measure periodically locked up by sleep during one quarter at least, if not one third of our whole existence; the limbs of the most athletic individual lose their power of motion after a few hours of unremitted exertion: even the brain, which during the hours of sleep and the interruption of all the common functions of the body frequently represents to the internal senses the most busy scenes of active life—even the brain may be exhausted by unusual fatigue, or other causes, and may thus involve the general system in the stupor of apparent death—but the heart, unless on such occasions as the momentary interruption of a swoon, never rests: so that, whether we look back to that period of our existence, when, in our yet imperfect state, there could scarcely be discovered the faint outline of those members, which in after life constitute man's strength and beauty, the presence of the heart may be recognised by the impulse of its vibratory motion, though its form is yet undefined, or at least indistinguishable; or whether, on the other hand, we look forward to the latest moments of protracted disease, or expiring old age, the same organ is the last part of our frame which continues to give immediate proof of vital motion.

The privation of light is rarely, if ever, total: for though the empire of time is divided in nearly equal proportion between day and night, there are comparatively few nights in which there is not diffused through the air a sufficient quantity of light for many of the purposes of life. Nor, with respect to those persons who either were born blind, or became blind in early infancy, is the absence of light felt with any degree of severity; for, in such instances, although the individual may be made to understand that he wants some faculty which those around him possess, there cannot be however any consciousness of privation where there never had been actually any enjoyment; or where there was no recollection of it, if it had for a time existed. And even in the case of individuals who have been deprived of sight long subsequently to birth, although the recollection of the former enjoyment must more or less imbitter their present state; yet so long as the offices of surrounding friends are the means of administering to their comfort, more especially if those offices are fulfilled with kindness, the mind soon becomes reconciled to the privation: for it is a fact, repeatedly observed, that blind persons under such circumstances are usually cheerful. Nor ought we to forget the compensation which nature affords to those who are deprived of sight, in the consequently quickened activity of some of the other senses.

Let us however suppose for a moment that, all the faculties and recollections of man remaining unaltered, and the general processes of nature continuing, if possible, the same as they are now, the existence of light were withdrawn from this earth: what would then be the condition of mankind? How could those occupations of life be pursued which are necessary for the supply of our simplest wants? Who in that case should yoke the ox to the plough, or sow the seed, or reap the harvest? but indeed under such a supposition there would soon be neither seed for the ground, nor grain for food: for, if deprived of light, the character of vegetation is completely altered; and its results, as far as general utility is concerned, destroyed. Or suppose, further, that these necessary supplies of life were no longer required, on account of some consequent alteration in our physical constitution; or that they were procured for us by any unknown means; yet, in all the higher enjoyments of our nature, how cheerless, how utterly miserable would be our situation. Under such circumstances, wisdom would not only be

"at one entrance quite shut out,"

but no other entrance could then be found for it; for of the other senses, the only remaining inlets of knowledge with reference to an external world, there is not one, which, if unaided by sight, could be of any practical value. With respect indeed to our inward feelings, though we should, on the one hand, be spared, by the privation of light, the worse than corporeal pain of the averted eye of those who ought to meet us with gratitude and affection; we should, on the other hand, lose the beams of filial or parental love; of which even a momentary smile outweighs an age of pain.

As in mathematical reasoning the truth of a proposition is sometimes indirectly proved by showing that every process of proof but the one proposed would lead to an absurd conclusion: so, though the supposition of a general and total privation of light is on all probable grounds of reasoning inadmissible, it may yet serve to show us indirectly the value of the good we enjoy. But it is sufficient to have given a few instances of the necessary effects of such a privation: and it will be a more grateful task to enumerate the actual benefits which we derive from the agency of light.

In the vegetable world, upon the products of which animal existence ultimately depends, light is the prime mover of every change that takes place, from the moment the germ emerges from the soil. Exclude the agency of light, and in a short time the most experienced botanist might possibly be at a loss to know the plant with which he is otherwise most familiar; so completely obliterated are all its natural characters, whether of colour, form, taste, or odour. Thus the faded colour of the interior leaves of the lettuce and other culinary vegetables is the result of such a degree of compression of the body of the plant as excludes the admission of light beyond the exterior leaves. And, again, if a branch of ivy or of any spreading plant happen to penetrate during the progress of its vegetation into a dark cellar, or any similar subterraneous situation, it is observable, that, with the total loss of colour, its growth advances with great rapidity but its proportions alter to such a degree as often to mask its original form. And, lastly, which in a practical point of view is of the greatest importance, if a plant which has grown without the influence of light be chemically examined, its juices, it might almost be said its whole substance, would be found to consist of little else than mere water; and, whatever odour it may have, is characteristic, not of its original nature, but of its unnatural mode of growth; becoming, in short, very like that of a common fungus. The total result is, that all the native beauties and uses of a vegetable growing under these circumstances are lost: the eye is neither delighted by any variety or brightness of colour; nor is the sense of smell gratified by any fragrance: the degeneracy of its fibre into a mere pulp renders it unfit for any mechanical purpose; and the resinous and other principles on which its nutritive and medicinal virtues depend, cease to be developed. In some instances, however, the bleaching or *etiolation* of plants is useful in correcting the acrid taste which belongs to them in their natural state; as in the case of endive and of celery.

The effect of light upon vegetation has been selected in the preceding paragraph as affording the most powerful instance of the adaptation of this natural agent to the physical condition of man. Its effects upon individuals of the mineral and animal kingdom are neither so easily to be traced, nor are nearly so important in their consequences, at least in a practical point of view; and therefore it is not proposed to bring them forward in a more particular manner.

The observation of those modifications which light undergoes when reflected from the surfaces of bodies has given rise to one of those impressive arts which are capable of contributing no less to the refinement of society at large, than to the gratification of the individuals who cultivate or admire them. For who can look on the productions of such masters as Guido, Raphael, or Michael Angelo, without imbibing a portion of the spirit which animated those masters in the execution of their inimitable works? or, if we quit the regions of imagination and of history, and descend from the higher efforts of the art into the retirement of domestic life, who can successfully describe those emotions which are excited by the portrait of a beloved object, a child or parent now no more; or by the representation of that home and its surrounding scenery, in which the careless and happy hours of childhood were passed?

The intrinsic source of the pleasure which we experience from the contemplation of a painting is probably to be sought for in that principle of our nature, of more extensive influence perhaps than is generally supposed, which derives a gratification from perceiving the resemblance of actual or probable truth; or even, and sometimes in a higher degree, from the delineation of fictitious characters and scenes: and hence the art of painting is easily made the vehicle of the ludicrous and the horrible, no less than of the sublime and the beautiful: and, hence also, the painter, may incur a considerable degree of moral responsibility in the exercise of his art. But this view of the subject, though fertile in reflections of great moment, and practically too much neglected, does not belong to the purpose of the present treatise.

Section III.

Heat.

From the consideration of the subject of light, the mind passes by a natural transition to that of heat: for these agents, though not necessarily or always, are in reality very often associated together: and they are each of them characterised by the want of that property which almost seems essential to matter, namely weight. In their relation to the physical existence of man and animal life in general, there is this difference between them—the presence of light is only indirectly necessary; the presence of heat is directly necessary. Different degrees of heat indeed are requisite for different species of animals: but if the heat to which any individual animal be exposed be much below that which is natural to the species, and be continued for a sufficient length of time, all the vital functions are eventually destroyed; or, as in the case of the hibernation of particular species of animals, are at least partially suspended.

The degree of heat adapted to the human frame is so nicely adjusted to the bodily feelings of man, that, if we take a range of fifty degrees of Fahrenheit's thermometer as indicating the average extent of variation to which the body is exposed in this climate, it will be found that a difference of two or three degrees, above or below a given point, will generally be sufficient to create an uncomfortable sensation. The late Mr. Walker, whose experiments on the artificial production of cold are well known to the philosophical world, ascertained that the point of 62° or 63° of Fahrenheit is that, which, upon an average of many individuals, is in this climate the most cogenial, as far as sensation is concerned, to the human body. But it is a merciful provision of nature, considering the numerous vicissitudes of human life, that man is capable of resisting very great and even sudden alterations of temperature without any serious inconvenience. Thus an atmosphere so cold, as to depress the mercury in Fahrenheit's thermometer to the 52d degree below the freezing point of water, has been borne under the protection of very moderate clothing. And, on the other hand, an atmosphere of a temperature as high as the 200th degree of Fahrenheit, which is within a few degrees of the boiling point of water, was borne by the late Dr. Fordyce, during ten minutes.* And it is highly worthy of notice, as connected with the general intention of this Treatise, that, during the same time, a thermometer which had been fixed under his tongue indicated only the 98th degree of Fahrenheit:* so that the body remained very nearly of its natural temperature, during its exposure to an atmosphere exceeding its own temperature by full 100 degrees.†

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* Phil. Trans. 1775. vol. lxv. p. 117.

This uniformity of animal temperature, under such circumstances, is in a great measure owing to the process of evaporation, which takes place from the general surface of the body, and from the air-vessels of the lungs: for if animals are confined in a chamber, the atmosphere of which is so moist that no evaporation can take place from the surface of their bodies, it has been found that their temperature is as capable of being steadily and uniformly raised, by increasing the heat of the room in which they are placed, as if they were inanimate matter.

The application of heat to the various purposes of life has a very extensive range; and with reference to the daily preparation of the more common forms of our food, whether animal or vegetable, distinguishes the habits of man from those of every other species. Without the power indeed of commanding the application of heat in its various degrees, many of the most important arts of civilized society would fail.

Without that power, how could clay be hardened into the state of brick, of which material most of the habitations in many large cities are constructed? Without the aid of the same agent, how could quicklime, the base of every common cement, be produced from limestone? Without the application of the higher degrees of heat, metals could neither be reduced from their ores, nor the reduced metals be worked into convenient forms. Neither, without the same aid, could that most useful substance glass be produced; a material, which in comparison hardly known to the ancients, has in modern times, become almost indispensably necessary to persons of the poorest class, as a substance of daily use for various economical purposes. But if we consider the properties of this valuable compound, with reference to the aid derived from it in the investigations of science, there are few substances of higher importance to the philosopher. Among the most useful of those properties are its impermeability to fluids, either in a liquid or aeriform state; its ready permeability to light, together with its power of modifying the qualities of that fluid; and its resistance to almost all those chemical agents, which are capable of destroying the texture of most other substances with which they remain long in contact.

In considering the extensive utility of the thermometer, and barometer, in their common and most convenient forms, it is evident that their practical value almost entirely depends on the transparency of glass, and on its impermeability to air: for if the glass, of which they are made, were opaque, the variations in the level of the quicksilver contained within them would be imperceptible to the eye; and could not be indirectly ascertained, unless by very circuitous and difficult means: and, on the other hand, if the glass were permeable to air, the variation in the level of the quicksilver, in the case of the barometer at least, would necessarily be prevented. The same properties of transparency and impermeability to air very greatly enhance, if they do not solely constitute the value of glass, in all those philosophical experiments which are carried on under what is called the exhausted receiver.

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* Ibid. p. 118.

† For an account of similar experiments carried to a further extent, see p. 484, &c. of the same volume of the Phil. Trans.

But the most important result of the transparency of glass is the modification which light undergoes in its passage through lenticular masses of that material. When, for instance, in consequence of disease or advancing age, the eye no longer retains the power of discerning objects distinctly, how much of hourly comfort, as well as of intellectual enjoyment, would be lost, were we not able to supply the natural defect by the artificial aid of glasses of the requisite form and density. And, again, how many important facts in the physiology of animals and vegetables, as also in the constitution of inanimate bodies, would have remained for ever undiscovered, but for the aid of the microscope; the magnifying powers of which depend on the transparency, and form, and the right adjustment of those pieces of glass through which the objects subjected to observation are viewed?

And, lastly, how shall we estimate the value of those discoveries, to say nothing of the constantly accumulating mass of observations connected with them, which the world owes to that wonderful instrument the telescope? By the aid of which not only has the knowledge of our own sidereal system been extended, in consequence of the discovery of new planets belonging to it; but it seems to have been rendered highly probable that those obscurely defined luminous masses, which Sir William Herschel termed *nebulæ*, observable within the limits of individual constellations, are really the accumulated light of innumerable stars seen through the medium of a space hitherto immeasurable: and that the *milky way* itsely is an extended accumulation of similar nebulæ; the collected light of which, at some inconceivable point of distance, may appear to the inhabitants of still more distant spheres, as a mere speck. Dare the mind attempt to penetrate beyond this general statement, and to speculate upon the characters of its detail? What if there be a resemblance, or even an analogy, between the structure and inhabitants of this earth and of the other planets of our system? What if every fixed star which we either see with the naked eye or by the aid of the telescope, or whose existence we can conceive on probable grounds by the mind's eye, be itself the centre of a system consisting, like our own, of numerous subordinate spheres, and every one of these inhabited by responsible agents, like ourselves; to whose uses both inorganic elements and animals and vegetables, analogous if not similar to our own, may be subservient? What if the moral history and state of the inhabitants of those numberless spheres be like that of man?—But the view, which the investigation of this question seems capable of unfolding, is too awful for the eye of reason; and, however its discussion might magnify our conviction of the infinite power and goodness of the Creator, is not to be approached perhaps without culpable presumption.

Let us therefore return to considerations more appropriate to the character of human knowledge: and, having referred to the effects produced by heat on various forms of matter, let us inquire what facilities nature has placed within our reach for the purpose of exciting and maintaining heat itself. The chemist in his laboratory, surrounded by the numerous and various agents which he is constantly employing, can never have any difficulty in producing the vestal element. By concentration of the sun's rays he may inflame any combustible substance: by compression of common air in a small cylinder of glass, or metal, he may ignite a piece of fungus, or inflame a piece of phosphorus, attached to the extremity of the piston which is employed to compress the air. He may instantaneously produce flame by pouring concentrated nitric acid on oil of turpentine, or on certain saline compounds; by the simple trituration of phosphorus, or other chemical agents; by directing a small stream of inflammable air on minute particles of platina loosely aggregated in a state somewhat resembling sponge; or, not to accumulate too many instances, he may delight himself for the thousandth time by igniting a fine wire of steel, in passing the electric current along it by means of the Voltaic apparatus.*

There are few individuals however who have commonly such magic instruments at hand: and, even if they had, it is probable that they would want both the leisure and inclination to preserve them in a state fitted to produce at any moment the intended effect; for, though each successive year has of late given birth to some new form of apparatus calculated to produce instantaneous light, we find ourselves constantly recurring to the flint and steel, which our forefathers of many generations have used; and which will doubtless be the staple apparatus of our latest posterity.

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* It will not perhaps be deemed impertinent, to relate an instance of the sagacity of the late Dr. Wollaston, in connexion with the present subject. It happened to the author of this Treatise, at a comparatively early period of his life, to deliver a letter of introduction to Dr. Wollaston at a moment when that philosopher was engaged in conducting an electric current, by means of the Voltaic apparatus, through three portions of fine steel wire, different from each other in diameter. With that vivacity of manner, which in him resulted rather from the simple consciousness of the acquisition of truth, than from the ignoble triumph of individual superiority, he asked which of those wires would first become of a red heat; and being answered, at a hazard rather than from any reasonable ground of conjecture, that the red heat would perhaps first take place in the thickest of the three—" I expect it will," he said, " and that the finest wire will never reach a red heat; for I conclude that, from its extreme fineness, the heat excited in it will be dissipated by radiation so rapidly, as to prevent the accumulation of a quantity sufficient for its ignition." It need hardly be added that the conjecture was verified.

As an instance of the minute scale on which Dr. Wollaston was in the habit of carrying on his philosophical investigations, it may be mentioned that the preceding experiment was conducted in a single cell of a single and moderately sized Voltaic trough.

The more important part of the present inquiry remains to be considered, the means namely of maintaining heat, when once excited, to a sufficient extent and degree of intensity for the various purposes of social and civilized life. To this important purpose, among others, the products of the vegetable world, both in a fossil and recent state, are destined; and in examining the origin and general history of some of these products, particularly with reference to common coal, we shall meet with an interesting example of those provisions of nature which Dr. Paley has denominated prospective contrivances.

In the early periods of civilization, and while the population of a country bears a small proportion to the extent of soil occupied, the indigenous forests easily supply an ample quantity of fuel: or in the absence of those larger species of the vegetable kingdom which may be described under the term of *timber*, the humblest productions of the morass, though not the most desirable, are however a sufficient substitute. Thus the *sphagnum palustre* and other mosses, by their successive growth and decay, form the combustible substratum of those extensive and at present uncultivated tracts in Ireland, which, till they shall have happily been reclaimed by the industry of a yet barbarous population, contribute by the turf and the peat which they afford, to the comfort of myriads of individuals; who, were it not for this source of supply, would be, in their present state, in total want of one of the principal necessaries of life.

In many populous districts of this island, the aboriginal forests, which formerly so amply supplied the surrounding inhabitants, have long since been cleared from the surface of the earth: and their site is now occupied by cultivated lands and a condensed population. The former source of fuel has consequently in such parts long since failed: but the clearing of the surface has in many places detected that invaluable mineral combustible, which, usually bearing in itself indubitable marks of a vegetable origin, from the traces of organization still apparent in almost every part of its substance, was deposited ages before it was wanted, as a future substitute for the fuel which in the meantime has been derived from the actually existing vegetable kingdom.

It is not intended here to enter into the general consideration of those geological formations called *coal fields*, which are the repositories of this useful mineral: but there is one circumstance in their history so evidently calculated to facilitate the labour of man in obtaining this substance, and to extend its supply, and so remarkably though not exclusively characteristic of those particular formations, that though not obvious to a general observer, it cannot fail to arrest the attention of those to whom it is pointed out. A coal field may be represented, in a popular description, as consisting of a succession of alternating strata of coal and sand-stone, &c.: which, having been originally deposited in a basin-shaped cavity, in such a manner as to be at the same time parallel to the concave surface of the basin and to each other, have been subsequently broken up by some force that has thrown the planes of the ruptured masses into various directions. Now, had the strata remained undisturbed, a very considerable proportion of the coal which is now quarried would most probably never have been obtained by human industry: for, the strata dipping down from the circumference towards the centre of the basin, that perpendicular depth, beyond which it is practically impossible to work the coal, would soon have been reached in the operation of mining. But, in consequence of the rupture and consequent dislocation of the strata, many of those portions which were originally deposited at such a depth beneath the surface as would have rendered the working of them impossible, have been thrown up to the very surface; and thus have become available to the miner.

Section IV.

The general Uses of Water.

One of the earliest political punishments of ancient Rome affords an indirect but very remarkable proof, of the immediate importance of the elements of fire and water* to human life: for this punishment consisting, in part, in an interdiction from the use of water, compelled the individual so punished to fly from his native neighbourhood, in order to obtain that necessary article of support elsewhere: and, hence, banishment and interdiction from fire and water became synonymous terms. There are few who have not experienced the uneasy sensation occasioned by even a temporary privation of this necessary: and the death that ensues upon a continued privation of it is, perhaps, of all modes of death the most dreadful. This we learn from the occasional accounts of individuals who have escaped from shipwrecks, in which their companions had perished amidst the agonies of thirst. And it is said of those unhappy victims of a barbarous punishment, in Persia, (who being immured in masonry, as to every part of their body but the head, are left to perish in that state,) that they terminate their last hours, perhaps days, in incessant cries for water.

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* An apology will hardly be required for applying the term *element* to a substance, which though it has long been experimentally ascertained to be a compound, will in a popular view be always considered as a simple body; especially if it be remembered that even among the ancients this term did not necessarily imply that the substance so called was absolutely a simple or uncompounded body. It was sufficient with them, that, in all the known processes and phenomena of nature, the substance presented itself under the same essential form: but they were prepared to allow that elementary bodies (στοιχεῖα) might possibly be resolved into absolutely simple principles (ἀρχαί).

The necessity of this element for our support may be antecedently inferred, on philosophical principles, from the examination of the physical composition of any animal body; of which, in by far the greater number of instances, more than three-fourths of the whole weight are due to the presence of water. This water of composition may be easily separated by the application of a moderate degree of heat, or even by spontaneous evaporation at a common temperature, without any further decomposition of the body; the muscles and skin consequently shrinking to such an extent, so as to give the whole frame the appearance of a skeleton, enveloped, as it were, in parchment. Such a result is occasionally observable in human bodies which have been deposited in dry cemeteries; and is by no means uncommon in the case of small animals, as rats, for instance, which having been accidentally wedged in between a wall and a wainscot, are subsequently found in the state above described.

An experiment of a very simple character in itself, and very easily made, will serve to ascertain, not only the proportional quantity of water of composition contained in some forms of animal matter, but also the properties communicated by the presence of that element thus combined. Every one has noticed the opaline or milky appearance and the remarkable elasticity of cartilage, or gristle, as it is more commonly called: which characters depend on the water contained in it; for if a piece of gristle, the weight of which has been previously ascertained, be exposed to the air of a warm room, it will at the end of a few hours have lost a portion of its weight; and will have become nearly transparent, and entirely inelastic: and if, in this state, it be immersed in water, it will gradually recover its original weight, and also its elasticity and opaline appearance. If, instead of gristle, a piece of boiled white of egg be employed, the same results will be observable; for, together with loss of weight and elasticity, it will become brittle, and nearly as transparent as pure amber: and on the other hand, by subsequent immersion in water, its original properties will be soon restored. By experiments nearly as simple as those above-mentioned it may be demonstrated, that all the liquid and solid parts of an animal, with some few exceptions, contain or consist of more than three-fourths of their weight of water: the importance of which element in the mere composition of our body is hence directly evident.

But if we would have a familiar illustration of its importance in the daily and hourly occurrences of life, let us in imagination accompany an individual of moderate rank and condition in society, from the time of his rising in the morning till the hour of sleep at night, in order to observe the utility of water in administering either directly or indirectly to his various wants and habits. How great is the comfort, to say nothing of the salubrity of the practice, which results to him from the application of water to the surface of the body, by means either of the bath or any simpler process! and, again, the change in the linen in which he is partially clothed is rendered equally comfortable and salutary, in consequence of its having been previously submitted to the process of washing. The infusion of coffee or of tea, which is probably an essential part of his earliest meal, could not have been prepared without water: neither could the flour of which his bread consists, have been kneaded; nor the food of his subsequent meal, the broths and most of the vegetables at least, have been rendered digestible, without the aid of the same fluid; and with respect to his common beverage, whether milk, or any form of fermented liquor, water still constitutes the main bulk of that beverage.

So far the use of water is directly and immediately necessary to his comfort and subsistence: but its indirect and remote necessity is equally observable in all that surrounds him. There is scarcely an article of his apparel, in some part of the preparation of which water has not been necessarily employed; in the tanning of the leather of his shoes; in the dressing of the flax of which his linen is made; in the dyeing of the wool of his coat, or of the materials of his hat. Without water the china or earthen cups, out of which he drinks, could not have been turned on the lathe; nor the bricks, of which his house is constructed, nor the mortar by which they are cemented, have been formed. The ink with which he writes, and the paper which receives it, could not have been made without the use of water. The knife with which he divides his solid food, and the spoon with which he conveys it when in a liquid form to his mouth, could not have been, or at least have not probably been formed, without the application of water during some part of the process of making them.

By water the medical principles of various vegetable and mineral substances are extracted, and rendered potable; which could not be introduced into the animal system in a solid state: and this element itself becomes occasionally a most powerful medicinal instrument by its external application, in every one of its forms; whether as a liquid, under the name of the cold or warm bath; or in the form of ice, in restraining internal inflammation and hemorrhage; or in the state of steam, as in the application of the vapour bath.

Section V.

Baths.

The custom of bathing, whether in a medium of a high or of a low temperature, appears to be in a great measure derived from the gratification of a natural feeling: for we find it prevalent in every country and in every stage of society, not only with reference to its medicinal effects, but as a mere luxury. Thus at every season of the year, when the sky is serene at least, the inhabitants of hot climates plunge into their native streams for the sake of the refreshment imparted to the surface of their bodies; and the same refreshment is equally sought by the natives of colder climates during the heat of their short summer: in each of which instances the pleasurable sensation is the principal motive for the practice. But on some occasions a more permanent good is sought; and the hope of immediate pleasure is so far from being the motive that a sensation very nearly allied to pain, and in many instances less tolerable than pain itself, is encountered in the shock of the cold bath, with a view to the preservation or restoration of health. It may be said perhaps that the glow of warmth which usually succeeds this shock is in itself a pleasure; as indeed it is: but it may be presumed that very few individuals experience any pleasure from the shock itself, or would consent to encounter it but for its pleasurable and beneficial consequences.

For the enjoyment of the cold bath nature affords the immediate resource of springs and rivers, in almost every part of the world; but the enjoyment of the warm bath is in general not easily attainable; warm springs being comparatively of rare occurrence: the pleasure of the warm bath however is so congenial to man's feelings, that it is sought for by savages as well as by the inhabitants of the most luxurious cities; and is as acceptable in tropical as in cold climates.

It is at all times interesting to contemplate the expedients which human ingenuity discovers for the accomplishment of its purposes: but such a contemplation is more particularly interesting when it developes the revival of a principle, the knowledge of which had been buried during many centuries of intervening ignorance; and thus justifies the reflection of moral wisdom:

> "Multa renascentur, quæ jam cecidere."

"The thing that hath been, it is that which shall be; and that which is done is that which shall be done: and there is no new thing under the sun."

In a most amusing and instructive account of Pompeii, which forms one of the volumes published under the name of the Library of Entertaining Knowledge, is a dissertation on the Baths of the Ancients; which will amply repay, by the information it conveys, the time occupied in its perusal. In that dissertation is contained a description of the remains of some public baths, discovered in the excavations of Pompeii: and with reference to the disposition of the furnace of the baths, a fact is stated, which is peculiarly applicable to our present purpose.

It is evident that, in consequence of the enormous quantity of water which was daily heated in their public baths, the attention of the ancients must necessarily have been directed to the most economical mode of applying the fuel by which the heat of the furnace was maintained: and the following extract from the above mentioned account of Pompeii will show that, even in a small town of ancient Italy, an economical principle was well understood and applied eighteen centuries since, which has only been of late revived in modern science. It is stated in that account (p. 152), that "close to the furnace, at the distance of four inches, a round vacant space still remains, in which was placed the copper for boiling water (*caldarium*); near which, with the same interval between them, was placed the copper for warm water (*tepidarium*); and at the distance of two feet from this was the receptacle for cold water (*frigidarium*). A constant communication was maintained between these vessels; so that as fast as hot water was drawn off from the caldarium, the void was supplied from the tepidarium, which, being already considerably heated, did but slightly reduce the temperature of the hotter boiler. The tepidarium in its turn was supplied from a general reservoir: so that the heat which was not taken up by the first boiler passed on to the second; and, instead of being wasted, did its office in preparing the contents of the second for the higher temperature which it was to obtain in the first. It is but lately that this principle has been introduced into modern furnaces; but its use in reducing the consumption of fuel is well known."

In the same account of Pompeii is afforded a striking instance, with reference to the vapour bath, not only of the similarity of the means employed for producing a similar effect, by individuals between whom no communication can be traced or even supposed; but also a similarity of custom, with reference to the enjoyment of social intercourse, between communities not less widely separated from each other by time and space, than by degree of civilization; between the luxurious inhabitants of imperial Rome eighteen centuries ago, and the savage tribes of North-western America at the present day. The author of the account of Pompeii states (p. 187—190,) on the authority of Tooke's Russia, "that the Russian baths, as used by the common people, bear a close resemblance to the vapour bath (*laconicum*) of the Romans. They usually consist of wooden houses, situated, if possible, by the side of a running stream. In the bath-room is a large vaulted oven, which, when heated, makes the paving stones lying upon it red hot; and adjoining to the oven is a kettle fixed in masonry for the purpose of holding boiling water. In those parts of the country where wood is scarce, the baths sometimes consist of wretched caverns, commonly dug in the earth close to the bank of some river. The heat in the bath-room is usually from 104° to 122° of Fahrenheit; and may be much increased by throwing water on the glowing hot stones in the chamber of the oven. The Russian baths therefore are vapour-baths; and it appears that even the savage tribes of America are not wholly unacquainted with the use of the vapour-bath. Lewis and Clarke, in their voyage up the Missouri, have described one of these in the following terms: 'We observed a vapour-bath, consisting of a hollow square of six or eight feet deep, formed in the river bank by damming up with mud the other three sides, and covering the whole completely, except an aperture about two feet wide at the top. The bathers descend by this hole, taking with them a number of heated stones, and jugs of water; and, after being seated round the room, throw the water on the stones till the steam becomes of a temperature sufficiently high for their purposes.'"*

It appears then, from the foregoing statement, that the peasants of Russia, and the savages of North America, are in the habit of employing the same means for converting water into vapour, which were employed by the Romans at the most luxurious period in their history: and to the peasants of Russia and the savages of North America, may be added the natives of New Zealand and other islands of the Pacific ocean; merely with this qualification, that they employ the steam, so raised, not for the purpose of a vapour-bath, but of dressing their food.

It is worthy of notice, as illustrative of the social feeling inherent in human nature, that, equally among the uncivilized natives of America as among the luxurious inhabitants of ancient Italy, "it is very uncommon for an individual to bathe alone; he is generally accompanied by one, or sometimes several, of his acquaintance: bathing indeed is so essentially a social amusement, that to decline going in to bathe, when invited by a friend, is one of the highest indignities that can be offered to him." (p. 190.)

SECTION VI.

The Fluidity of Water.

FAMILIARIZED as we are to the consequences resulting from that property of water, whereby its particles move so easily among themselves as to yield to the least impulse, provided there be space for yielding, we rarely perhaps meditate on its importance: and yet it is entirely owing to this property that a free communication is capable of being maintained between distant parts of the world by means of the ocean at large, and between different parts of the same country by means of navigable rivers; or by those more than rivals of navigable rivers, artificial canals.*

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* Sauer, in his account of Billings' expedition, describes the same kind of bath as used in north-western America (p. 175.)

Rarely also, perhaps, do we meditate on the equally important fact, that, throughout the greater part of the world this element usually exists in a liquid state: and important indeed is that fact; for, of the three states under which it is capable of existing, namely of ice, water, and vapour, if its predominant state had been that of ice or of vapour, philosophers might possibly have conjectured, but the world could never have seen realized, the mighty results of commerce as depending on the art of navigation.

From the same physical character of water, above described, namely its fluidity, manifesting itself actively instead of passively, are daily produced results of equal importance to society, and equally surprising in themselves. Who indeed can adequately describe the advantages derived from water in aiding the powers of mechanism, from the half-decayed and moss-grown wheel that scarcely sets in motion the grinding-stone of the village mill, to the astonishing momentum of the steam engine which kneads a hundred tons of heated iron with as much ease as the hands of the potter knead a lump of clay!

And here, since it is of the utmost importance to mankind that this element should usually exist in a liquid state, let us pause a while to investigate the means employed by nature to prevent its rapid conversion either into vapour or into ice. For although its partial existence in both those states is perhaps eventually as necessary to the general good of the world as its more common state of water, yet, if its sudden or rapid conversion into either were not prevented, great temporary evil would necessarily ensue from our privation of it as a liquid.

It has been already mentioned that the atmosphere constantly holds in solution or suspension a great body of water, in a state of minute division: but the quantity that can be carried up into the atmosphere by the process of evaporation is limited in two ways; first, by the air's incapability of holding in suspension more than a certain proportion; and secondly, by the restraining effect of the pressure of the atmosphere. But the rapid evaporation of water is also prevented by the comparatively low temperature at which all its natural forms exist, even in tropical latitudes.

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* It has been stated, on credible authority, that an agent of a great proprietor of canals being incidentally asked, during a legal examination, for what purpose he conceived rivers had been made, answered, "that, no doubt, they were intended to feed canals."

The prevention of the sudden conversion of water into ice depends on a peculiarity in its physical constitution, which is no less remarkable in a simply philosophical point of view, than beneficial in its result to the great bulk of mankind. Water, in common with all other forms of matter, is gradually contracted in its volume by a dimunition of its temperature; and ultimately passes into a solid state. It does not however continue to be condensed to the moment of its congelation, but only to a certain degree of temperature; from whence it begins to expand; and continues to expand till it arrives at the point of congelation.

In this deviation from a general law we find a very beneficial accommodation to the wants of man: for had it been the property of water to become more and more condensed as it approached the point of congelation, one of the consequences would have been that lakes and rivers, instead of becoming gradually frozen from the surface towards their bed, would almost in a moment have become one solid mass of ice: and the evil that would be produced by such an effect may be conjectured, by considering that whenever a long protracted and severe frost has thickened to an unusual extent the superincumbent stratum of ice, the difficulty of breaking through the stratum, in order to arrive at the water beneath, is proportionally increased, and sometimes becomes practically insuperable.

It will be interesting to trace the steps by which this providential law of nature is manifested: and the whole process is easily rendered intelligible to any one who will simply bear in mind these three points, namely, that the average temperature of lakes and rivers is during the heat of summer more or less above the 40th degree of Fahrenheit's scale; that water itself at about the 40th degree is of its greatest density; and that under all common circumstances it freezes, or becomes solid, at the 32d degree. If we suppose then the temperature of a pool or lake to equal at any given moment the 50th degree of Fahrenheit; and a gradual reduction of its temperature to take place from that moment by the effect of a constantly diminishing temperature of the air; under such circumstances the following phenomena would occur. The particles of the water at the surface becoming more condensed, that is heavier, as they become cooler, would sink towards the bottom, and be replaced by the hitherto subjacent particles; which in their turn, undergoing a similar decrease in their temperature and condensation, would consequently subside towards the bottom; till at length the whole mass of water had arrived at the temperature of about 40°. From this point any progressive decrease of temperature would have an expansive effect upon the particles of water near the surface; which, being thus rendered relatively lighter than the particles of the subjacent mass, would not subside; but, remaining on the surface, would continue to be expanded and made still lighter till they had reached the temperature of 32°; at which degree, under ordinary circumstances, they would freeze. But the coat of ice thus formed would be, in some measure, a barrier to the effect of the colder atmosphere upon the bulk of the water beneath; which consequently would remain for a comparatively longer time in a liquid state; and would be easily procured for general purposes, by making partial openings through the frozen surface. Now if the density of water continued to increase in a regular progression to the moment of congelation, it would necessarily happen, from the sinking of the particles gradually thus condensed, that at some given moment the temperature of the whole mass, still in a liquid state, would have arrived at the freezing point; and consequently the whole mass would have been frozen, or become solid, at the same moment. The possibility of such a simultaneous congelation is not merely a philosophical deduction, it sometimes actually occurs. Thus, under certain circumstances, particularly if kept entirely free from agitation, water, still retaining its liquid form, may be cooled down to a point several degrees below that of congelation; when, upon a slight agitation, the whole mass is converted at once into the state of ice.

Section VII.

The natural Sources of Water.

For the supply of a substance of such immediate necessity to the very existence of man, and of such extensive utility in promoting his comforts, nature has provided the amplest means; all however ultimately derived from that mass of water which has been carried up into the atmosphere by evaporation from the sea: so that if that evaporation were to fail, all forms of animal and vegetable matter, with the exception of those which belong to the ocean itself, would soon perish; for under such circumstances the earth would be deprived of those seasonable showers, without which its vegetable productions could not be sustained; and every spring would soon fail, and every river be dried up: for rivers are in most instances formed by the progressive accumulation of various torrents; and these are produced by that portion of rain which, having fallen upon the ridges and inclined surfaces of hills and mountains, descends more rapidly than the soil can absorb it: and springs result, in a manner that will be hereafter mentioned, from the accumulation of that portion of the rain which sinks beneath the surface on which it has fallen. But it is evident that if the vegetable world were to perish, the animal world could not long survive.

Nor are the laws by which the moisture, contained in the atmosphere, is precipitated from it in dews or rain, among the least admirable instances of the provision made by nature for a constant supply of the wants of man.

The mechanism, if the term be allowable, by which the formation of clouds and the occasional descent of rain are regulated, resides in the variableness of the state of the heat and electricity of the atmosphere: in consequence of which a given mass of air is incapable of retaining, in solution or suspension, the same quantity of moisture which it did before; and hence that moisture is precipitated in the form of dews and fogs; or, being previously condensed into accumulated masses of clouds, is discharged from those clouds in the form of rain.

It almost seems puerile to illustrate the adaptation of the present laws and order of nature to the wants of man, by the supposition of the consequences that would ensue from a failure of those laws; and yet, as in actual life we often feel not the value of the good which we possess, till admonished by the prospect of its loss; so, with reference to the constitution of nature, we may more forcibly be impressed with the conviction of its general harmony and subserviency to our wants, by the supposition of its being different from what it is, than by the direct contemplation of its actual state. In supposing then that means had not been provided for the regular discharge of portions of that mass of water which has been carried up into the atmosphere by the process of evaporation, the existence of that mass would have been of little avail to man: for mere contact of an atmosphere, however moist, could not promote vegetation to any useful extent;* and the formation of springs and rivers would be as effectually prevented by rain ceasing to fall from the atmosphere, as if the material of the rain itself did not exist in it.

Of the modes in which nature disposes of the rain that has fallen on the earth, and of the formation of natural springs and rivers, more particular notice will be taken hereafter: but it may be observed by the way, that, although there is scarcely any substance which water is not capable of dissolving to a certain extent, and consequently no natural form of water is pure, yet in almost every instance the natural forms of water are not only innocuous, but salutary.

Section VIII.

The Air of the Atmosphere, as connected with Respiration.

If we suppose the atmosphere deprived of heat, and light, and moisture, and of all those other heterogeneous particles which are either naturally or accidentally contained in it; there still remains the medium which is the receptacle or vehicle of those various substances: and this medium is indeed that, which in common apprehension is understood to be the atmosphere itself.

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* Niebuhr asserts, what is confirmed by other travellers, that many tracts in Egypt and Palestine, formerly well cultivated and fertile, are at present mere deserts for want of irrigation. (Descript. de l'Arabie, p. 241.)

Of the vital importance of atmospherical air no formal proof can be required; for every one capable of the least reflection must know that its presence is almost constantly necessary to the existence of man, from the moment of his birth to that of his death. Of all other external aids we may be deprived for a comparatively long time without danger, or even without much inconvenience; of light and heat for instance, and of food and sleep: but we cannot be deprived of the air which we breathe even for a very few minutes, without dreadful distress; or, if for more than a very few minutes, without the extinction of life.

This vital importance of the air depends, principally, on its capability of assisting to withdraw from the body, chiefly through the agency of the lungs, portions of that peculiar principle called *carbon;* the permanent retention of which would be incompatible with the continuance of life. And the union of this principle with one of the constituent parts of atmospherical air is probably effected in the lungs during the process of respiration; the compound passing off in the act of expiration, in the state of an aeriform fluid, called *carbonic acid gas.*

But, in order to give a clear idea of the nature of the process of respiration, it will be necessary to explain more particularly not only the constitution of that portion of the atmosphere which supports this process, but some of its chemical relations to other substances. Atmospherical air then, considering it in its adaptation to the process of respiration, consists of a mixture or combination of two aeriform fluids, which are very different from each other in character, but intimately blended together in the proportion of four to one. Of these two fluids, that which is in the smaller proportion is not only capable of supporting life, when respired or breathed alone; but is capable of supporting it for a much longer period than an equal volume of atmospherical air would have supported it: and if, instead of being employed for the process of respiration, it be made the medium of supporting combustion, the consequent phenomena are still more remarkable; for the combustible body not only burns for a longer time than it would have done in the same quantity of atmospherical air, but it burns with an intensity much more vivid; the light of the flame being in many instances too powerful to be easily borne by the eye. On the other hand, that constituent part of atmospherical air, which is in the greater proportion, not only will not support either life or flame, even for a short time, but extinguishes both, almost in an instant.

By numerous experiments, which it is at present unnecessary to describe, it has been ascertained, that many of the metals are capable of attracting and combining with this respirable part of the air: during which process the metallic body assumes an earthy character, and becomes increased in weight; while the weight of the air, in which the experiment has been conducted, becomes diminished exactly to the amount in which that of the metal has been increased: and, at the same time, the residuary portion of the air which has been employed in the experiment equals only about four-fifths of the original volume; and is now incapable of supporting either life or flame. But, by processes well known to chemists, the metallic substance may be made to yield a quantity of air equalling that which has been lost during the experiment, the metal at the same time returning to its original state and weight; while the air, thus separated, if added to the residual portion, not only restores the volume and weight of the original quantity; but also its power of supporting life and flame.

If, instead of a metal, certain inflammable substances be employed, similar changes are effected on the air; and the inflammable substance, together with an increase of weight and other alterations, acquires acid properties; and hence that respirable portion of the air has, from a Greek derivation, been called *oxygen;* as being the effective cause of the acidification of those inflammable bodies. It has moreover been ascertained that, during combustion, a piece of pure charcoal weighing twenty-eight grains combines with as much oxygen gas as would weigh seventy-two grains: and, as the volume of the gas employed remains the same at the end of the experiment that it was at the beginning provided it be brought to the same degree of temperature and atmospherical pressure, it appears that the carbon is as it were held in solution by the gas: and as this chemical compound of carbon and oxygen possesses acid properties it is called *carbonic acid gas.*

A volume of this gas, then, which weighs one hundred grains, consists of twenty-eight grains of carbon chemically combined with seventy-two grains of oxygen: and it has certain properties, by which, without the labour of actual analysis, it may be recognised from any other gas; among the more important of which, for our present purpose at least, is the readiness with which it communicates a wheyish appearance to lime-water, when made to pass through that liquid. Making use of this character as a test, any individual may easily satisfy himself that during the process of respiration a quantity of carbonic acid gas passes from his lungs: for if, after having inhaled a portion of atmospherical air uncontaminated with any mixture of it, he breathe slowly through a narrow tube, the further extremity of which is immersed beneath the surface of a portion of lime-water, he will observe that as the bubbles of air rise through the lime-water, that liquid becomes opaque; and the opacity thus communicated to the water can be shown to be the result of a compound formed by the union of the carbonic acid, which has evidently been given out from the lungs, with the lime previously held in solution in the lime-water.

Let it now be kept in mind that a hundred cubic inches of carbonic acid gas, under ordinary circumstances, weigh a little more than forty-six grains; and that a quantity of the same gas weighing a hundred grains contains twenty-eight grains of carbon; and the following statement will be easily intelligible. It appears, from experiments which have been made for the purpose, that during the process of respiration in an individual of ordinary size and health, about twenty-seven cubic inches and a half of carbonic acid gas are given off from the lungs in the course of one minute; which at the end of twenty-four hours would amount to 39,600 cubic inches, or in round numbers 40,000; and as 100 cubic inches weigh 46⅓ grains, 40,000 would weigh 18,532 grains. Then since a quantity of carbonic acid gas weighing 100 grains contains twenty-eight grains of carbon, a quantity weighing 18,532 grains would contain 5190 grains, or nearly eleven ounces, at 480 grains to an ounce: so that a quantity of carbon equalling two thirds of a pound in weight is daily discharged from the blood by means of the simple process of respiration.

In an illustration of the general question of the adaptation of external nature to the physical condition of man, it is clearly immaterial whether, during the process of respiration, the carbonic acid is supposed to be produced by the union of the carbon of the animal system with the oxygen of the air respired; or whether, as is possible, the carbonic acid, having been previously formed in the body at large, is given off in the form of carbonic acid gas from the lungs, while the oxygen gas of the atmosphere is absorbed by those organs. The main point to be considered is, the fact of the removal of that quantity of carbon, which could not be retained with safety to the life of the individual: and when we consider that the entire quantity of the carbon, thus discharged, is collected from every the most interior and remote part of the body, how worthy of admiration is the economy of nature in producing the intended effect! The air is the medium through which the carbon is to be discharged; and yet the constitution of the body is such, that the air could scarcely be introduced into any of its internal parts without occasioning the most serious consequences, if not death itself: but by means of the circulation of the blood, that beautiful contrivance intended primarily for sustaining the nourishment and warmth and life of every part, the noxious principle is conveyed to the lungs: where it is of necessity brought, if not actually, yet virtually, into contact with the air; and thus it is effectually removed from the system.

SECTION IX.

Effects of the Motion of the Air, as connected with Human Health, &c.

IN the history of water we had an opportunity of observing how extensive are the benefits arising to mankind from that physical property, by which its particles are capable of moving with the greatest ease among each other: nor are the benefits less considerable, which arise from the same property in the element now under consideration; especially when aided by those alterations in its volume, which follow upon every change of temperature: for from these combined causes arise those currents of air, which administer, in various modes, as well to the luxury and comforts of man, as to his most important wants.

Who does not see the miseries that would result from a stagnant atmosphere? To the houseless and half-clothed mendicant indeed, who under exposure to a wintry sky instinctively collects his limbs into an attitude as fixed as marble, lest by their motion he should dissipate the stratum of warmer air immediately surrounding his body—to such an individual indeed, under such circumstances, a stagnant atmosphere becomes a benefit of the highest value; not only by preventing or moderating the painful sensation of cold; but by preventing the dissipation of that degree of heat which is necessary for the preservation of the vital principle, which in his unsheltered state might otherwise possibly be soon extinguished. But let circumstances be reversed; and, instead of the wretched beggar exposed to an inclement sky, let us picture to ourselves an Asiatic prince surrounded by all the luxuries which power and opulence can procure, but oppressed by the sultry atmosphere of a burning sun; how grateful to his feelings is the refreshing coolness occasioned by the artificial agitation of the surrounding air: in order to extend the means of obtaining which gratification, fountains of water are customarily introduced into the interior rooms of Indian and Arabian palaces, the evaporation of the spray of which gives a refreshing coolness to the air. Or let us recur to scenes more familiar, and more illustrative of the effect produced; to the bedside of the almost exhausted invalid, whose existence is alone made tolerable by the assiduous supply of fresh streams of air: there let us witness, in the thankful smile which animates his pallid countenance, the soothing sensation which the languid sufferer experiences. Even for such a momentary solace, what, of all his most valuable possessions, would not every one of those miserable victims have surrendered, who once perished in that dreadful dungeon of Calcutta?

In many instances nature tempers the high degree of heat belonging to particular climates, by the periodical recurrence of cooling winds at stated hours of the day. Thus, in the islands and on the coasts in general of the tropical regions of the earth, the alternations of what are called the sea and the land breeze are of the highest importance to the comfort and health of the inhabitants: of which the following statement, taken from an official paper on the medical topography of Malacca, furnishes a sufficient illustration.*

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* Printed at the government press, Pinang, 1830. See the Edin. Med. and Surg. Journal, for July 1831, p. 179

"The Malay peninsula possesses, though within the tropics, and almost under the equator, a very equable temperature and mild climate. Whatever be the prevailing wind, the sea-breeze generally sets in from the south between ten and twelve in the morning, and continues till six or seven in the evening; when, after a short calm, the land wind begins to blow from the north-east: and so constant are these breezes, that, unless during a storm, the influence of the monsoon is scarcely perceptible. And so uniform is their effect, with respect to the temperature of the air, that, throughout the year, the variation does not exceed fourteen or fifteen degrees of Fahrenheit: being rarely higher than eighty-eight degrees, or lower than seventy-four degrees."

And though the hurricanes, to which these regions are frequently exposed, are occasionally most dreadful in their effects upon the property and even the lives of the inhabitants; yet we may not only be assured on general principles of reasoning that in the main they are beneficial, but on some occasions we have immediate demonstration of their remedying a greater evil. Thus when swarms of a peculiar species of ant had, during many years, ravaged the island of Grenada, to so serious an extent that a reward of twenty thousand pounds had been offered to any one who should discover a practicable method of destroying them; and when neither poison nor fire had effected more than a partial and temporary destruction of them, they were at once swept away by a hurricane and its accompanying torrents of rain. Of the numbers in which these insects occurred, some estimate may be formed from the following statement of an eyewitness of credible authority; who says "he had seen the roads coloured by them for many miles together; and so crowded were they in many places, that the print of the horse's feet was in a moment filled up by the surrounding swarms."*

We who rarely are oppressed, for more than a few hours in a whole summer, by such a state of the atmosphere as occasionally precedes a thunderstorm, when no friendly breeze interposes to remove the close and humid stratum of air which envelopes our bodies, may well be thankful that our lot has not been cast in certain regions of the earth; in those Alpine valleys, for instance, whose scarcely human inhabitants attest the dreadful consequences of a confined atmosphere: the influence of which often affects not only the present sensations and comforts, but even the intellectual, and eventually the moral character, of those who are habitually exposed to it.

It appears, from recent inquiries, that the physical and intellectual and moral degradation, so often observable in the inhabitants of mountain valleys in general, but noticed particularly in the valleys of the Rhone, may be referred with probability, among other causes, to a stagnant atmosphere; and to the reverberation of heat from the sides of the mountains which bound those valleys, co-operating with an alternation of piercing winds: the degree of that degradation at least is always proportional to the action of those causes.

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* Philos. Trans. 1790, p. 347.

It is not necessary here to dwell minutely on the disgusting alteration which the human beings, now particularized, undergo: those who are desirous of such information may consult a very recent work by Dr. James Johnson.* All that is here intended is a statement of the general fact. And it appears that, in the milder instances, the principal alteration which takes place is an enlargement of the thyreoid gland; which enlargement is by medical men called *bronchocele*, and by the inhabitants of the Alps *goitre*.† In the instances of extreme alteration, the stature rarely reaches the height of five feet; the skin becomes unnaturally discoloured, and disfigured by eruptions; the limbs distorted; and the *cretin*, for so he is denominated in this state, is frequently, in addition, both deaf and dumb, and entirely idiotic. Between the state of simple goitre and that of most perfect cretinism the degree of alterations are innumerable. And, as indicating the connexion between this unnatural state of the individual, and the atmosphere which he habitually respires, the following observation is worthy of attention. "In the Vallais," and "in the lower gorges or ravines that open on its sides, both cretinism and goitre prevail in the most intense degrees: as we ascend the neighbouring mountains, cretinism disappears, and goitre only is observed; and when we reach a certain altitude, both maladies vanish."‡

Among the physical effects of the motion of the air, that of sound is among the most remarkable and important: of the intimate nature of which, however, and of the laws that regulate its transmission, I should not speak more particularly, even if I felt myself competent to the task; being a subject of too abstruse a character in itself to claim a close investigation in a treatise like the present: besides which, it will be examined in a separate treatise by others. Whatever may be the moral effects either of simple sounds, or of certain combinations of sounds, and such effects though apparently of a fugitive character are occasionally very powerful, there can be no doubt that particular sounds act physically on our frame. Thus the gentle murmur of running water, or the repetition of any simple tone, even though not agreeable in itself, is calculated to soothe the whole nervous system so as to induce sleep. There are few perhaps who have not experienced such an effect, from long continued attention a to public speaker; and an apparent, though probably not the legitimate, proof of the effect having been produced by the sound of the voice of the speaker is derived from the fact, that upon his ceasing to speak, the sleeper usually awakes. There are few, again, who have not known from personal experience that certain tones affect the teeth with that peculiar and unpleasant sensation familiarly described under the term, *set on edge.* Even in the appalling sensation excited by thunder, the mind is probably overawed by the physical effect produced on the nervous system by the crash, rather than by any apprehension of danger from the thunder itself: for that sensation is usually excited even in those who are most assured that no danger is to be expected from the loudest crash of the thunder, but only from the lightning which accompanies it. Nor is it unreasonable to suppose that an analogy exists between the sense of hearing and the other senses, with reference to the objects of their several sensations: and since in the case of taste, of sight, of smell, and of touch, some objects are on reasonable grounds conjectured to be naturally offensive, while others are agreeable to the respective senses; why, it may be asked, should not the same relations hold with respect to the ear and the peculiar objects of its sensation? Evelyn well observes, that the bountiful Creator has left none of the senses which he has not gratified at once with their most agreeable and proper objects.

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* Change of Air, &c. by James Johnson, M. D. London, 8vo. 1831.

† Such an enlargement we often in this country witness in individuals, who, in every other respect, are so far from being deformed, that they are frequently remarkable both on account of their beauty, and the symmetry and full developement of their whole body.

‡ Change of Air, &c. p. 58.

Of all the objects of sense, sound perhaps, as a principle of mental association, the most powerfully excites the recollection of past scenes and feelings. Shakspeare briefly elucidates this principle in these lines:

> " Yet the first bringer of unwelcome news
> Hath but a losing office; and his tongue
> Sounds ever after as a sullen bell,
> Remembered knolling a departed friend."
>
> HENRY IV. Part II. Act I. Scene 1.

The author of the "Pleasure of Memory" not less forcibly illustrates the same principle.

> "The intrepid Swiss, who guards a foreign shore,
> Condemned to climb his mountain cliffs no more,
> If chance he hear the song so sweetly wild,
> Which on those cliffs his infant hours beguiled,
> Melts at the long-lost scenes that round him rise,
> And sinks a martyr to repentant sighs."
>
> ROGERS, &c. page 21, line 1.

Nor is the principle less powerfully illustrated in that most beautiful Psalm beginning with the words, "By the waters of Babylon we sat down and wept:" for who can read that affecting apostrophe, "How shall we sing the Lord's song in a strange land," without entering into all the pathos of the scene represented by the sacred poet to the imagination?

It is said to be the opinion of the Hindoos, and though not of much value in argument, there is at least a metaphysical elegance in the opinion, that the remarkable effects of music on the human mind depend on its power of recalling to the memory the airs of paradise, heard in a state of pre-existence.

But, if an individual instance of the truth of the present position were to be selected, it would not be possible perhaps to find one more impressive than that which has been recorded of the late emperor of the French. It is said that at that period of his life, when the consequences of his infatuated conduct had fully developed themselves in unforeseen reverses, Napoleon, driven to the necessity of defending himself within his own kingdom with the shattered remnant of his army, had taken up a position at Brienne, the very spot where he had received the rudiments of his early education; when, unexpectedly, and while he was anxiously employed in a practical application of those military principles which first exercised the energies of his young mind in the college of Brienne, his attention was arrested by the sound of the church clock. The pomp of his imperial court, and even the glories of Marengo and of Austerlitz, faded for a moment from his regard, and almost from his recollection. Fixed for a while to the spot on which he stood, in motionless attention to the well known sound, he at length gave utterance to his feelings; and condemned the tenour of his whole subsequent life, by confessing that the hours, then brought back to his recollection, were happier than any he had experienced throughout the whole course of his tempestuous career. He might perhaps with truth have added, when looking at the various objects of the surrounding scenery,

> "I feel the gales, that from ye blow,
> A momentary bliss bestow."

Perhaps also during this moment, and in making a confession so humiliating, he actually did experience that moral state represented by Milton to have been felt by the fallen angel—

> "Thrice he essayed (to speak); and thrice, in spite of scorn,
> "Tears, such as angels weep, burst forth—"

But the effect produced on his mind seems to have been momentary; at least it certainly did not alter his course of action. And too probably he was at that time rather tormented by remorse, than softened by repentance; a state but little favourable to the adoption of better counsels, even if he could then have retrieved his fortunes by such a change.

Section X.

Effects of the Motion of the Air, as connected with the Arts, &c.

I proceed now to consider the effects of the atmosphere, while in a state of motion, in aiding the various arts and operations of civilized society; in which the action is sometimes explicable on mechanical, sometimes on chemical, or on physical, principles.

It would not be a short or easy task to enumerate the various substances which require to be deprived of all sensible moisture, in order to be applicable to the immediate purposes of life; nor in order to be capable of being preserved in a state fit for future use: and the separation of that moisture which they may contain in their natural state, or which they may have accidentally contracted, can in general only be effected by exposure to the open air: but as that portion of the air, which is in contact with the moistened substance, would soon be so far saturated with the vapour arising from it as to be incapable of absorbing more, it must necessarily be replaced by successive portions of fresh air; in order that the substance may be thoroughly dried: and hence we see the advantage of currents of air, or, in common language, of the wind, for the purposes in question. Without the aid of such currents, the grass newly mown would often with difficulty be converted into hay: and with still more difficulty would that conversion take place should it during the process, as is most likely to happen, be exposed to rain. The same difficulty would occur, but attended with much more serious effects, in the case of sheaves of wheat or barley, which having been once drenched with rain would be rendered unfit for producing bread, unless the moisture were soon dissipated: and with respect to the process of reducing the corn itself to the state of meal, that is, in common language, of grinding it; although many other mechanical means are capable of being applied to that purpose, who does not see the advantages of the common windmill, even where other means are available, which in many places they would not be? but windmills would themselves be unavailable, were there no currents of air to set them in motion.

In the drying of moistened linen, and of paper newly made; in the seasoning, as it is called, of wood; and on numerous other occasions, the same advantages occur from the same cause, and are explicable in the same way. But there is one instance, of very familiar occurrence, where the effect of a free ventilation is productive of the greatest comfort. At the breaking up of a long protracted frost, during which the air has been enabled to absorb and retain in an insensible state an unusual quantity of moisture, that moisture, as soon as the thaw takes place, is deposited upon the surface of every thing with which it comes in contact: and there can be scarcely an individual, from the peasant to the noble, who has not often experienced the comfortless state of the interior of his habitation from this cause. The opulent indeed, supposing that nature did not provide the remedy, might easily remove, and often do accelerate the removal of the evil, by the introduction of currents of air artificially heated: but the indigent, incapable of commanding so expensive a remedy, would meet with serious detriment, did not a timely change in the state of the atmosphere enable it to re-absorb the moisture which had previously been discharged from it; for many parts of the furniture of their habitation would be injured, or even destroyed by the moisture imbibed by them: and with respect to a much more important point, a healthy state of body, both the opulent and the indigent would be alike sufferers, from a continued exposure to the external atmosphere in such a state.

In the foregoing instances currents of air have been considered as acting on a fixed point as it were, or on bodies nearly stationary. Let us now consider their action on bodies capable of being set in motion, as nautical vessels of all kinds, and we shall not fail to see the importance of that action to some of the highest interests of man.

To those, of whatever condition in life, who are surrounded by the numerous resources of a commercial city, it is immediately of little import, unless as a question of mere corporeal feeling, whether the air be in a state of perfect calm, or freshened by a breeze; and whether that breeze be from the east, or from the west. To the agriculturist even it is comparatively of little interest, unless at particular seasons, whether the wind be high or low, or from what quarter it may come; further than as particular states and directions of the wind are indications of rain or drought. But to those "who go down to the sea in ships, and occupy their business in great waters," not only the degree of force, but the direction of the wind, is of the highest moment: while on many occasions, even in the present advanced state of science and naval architecture, a motionless state of the atmosphere, or a calm, might be fatal to all their speculations. Every one who has lived for a time on the sea-coast must have observed with what anxiety the owner of the smallest fishing boat watches the variations in the state or direction of the wind, as connected with the practicability of putting out to sea. If the wind be in an unfavourable quarter, or if it blow not with sufficient force to swell his sails, he saunters in listless inactivity along the beach: but if the wished for breeze spring up, the scene is at one changed, and all is alacrity and life.

In some parts of the world Providence has compensated for the disadvantages arising from the general uncertainty of the wind, by the continued regularity of its direction through stated seasons: in consequence of which, the merchantman calculates upon the commencement and duration of his voyage with a degree of security and confidence, which sets him comparatively at ease as to the event. These periodical currents of air indeed have been named from this very circumstance the *trade winds:* and, in illustration of their adaptation to the purposes of commerce, a more striking instance perhaps could not be adduced than the following, which is given in a volume, entitled, "Four Years Residence in the West Indies," written by a gentleman by the name of Bayley.* In the description of the island of St. Vincent it is there stated that a little sloop, the private signal of which was unknown to any of the merchants, sailed into the harbour one morning, and immediately attracted the notice of the surrounding crowd; and the history of its unexpected appearance is thus given. "Every one has heard of the little fishing smacks employed in cruising along the coast of Scotland; which carry herrings and other fish to Leith, Edinburgh, or Glasgow, worked by three or four hardy sailors, and generally commanded by an individual having no other knowledge of navigation than that which enables him to keep his dead reckoning, and to take the sun with his quadrant at noonday.

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* London, 8vo, 1830, p. 292.

"It appears that a man who owned and commanded one of these coasting vessels had been in the habit of seeing the West India ships load and unload in the several ports of Scotland; and, having learned that sugar was a very profitable cargo, he determined, by way of speculation, on making a trip to St. Vincent, and returning to the Scottish market with a few hogsheads of that commodity. The natives were perfectly astonished—they had never heard of such a feat before; and they deemed it quite impossible that a mere fishing smack, worked by only four men, and commanded by an ignorant master, should plough the boisterous billows of the Atlantic, and reach the West Indies in safety; yet so it was. The hardy Scotchman freighted his vessel; made sail; crossed the bay of Biscay in a gale; got into the *trades;* and scudded along before the wind, at the rate of seven knots an hour, trusting to his dead reckoning all the way. He spoke no vessel during the whole voyage, and never once saw land until the morning of the thirty-fifth day; when he descried St. Vincent's right a-head: and setting his gaft-topsail, he ran down under a light breeze, along the windward coast of the island; and came to anchor about eleven o'clock under the circumstances before mentioned."

Such a vessel, and so manned, could hardly have performed the voyage here described, had it not been aided by the current of the trade wind: and what then must be the advantage of such a wind, when, instead of aiding the puny enterprise of a single and obscure individual, it forwards the annual fleets of mighty nations. Most important therefore to the Roman empire was the discovery of Hippalus, which enabled its fleets to stretch across at once from the African to the Indian coast by means of the south-westerly monsoons. But, if we would view the subject in all its magnitude, let us contemplate with a philosophic eye the haven of any one of the larger sea-ports of Europe; filled with vessels from every maritime nation of the world, freighted not only with everything which the natural wants of man demand, or which the state of society has rendered necessary to his comfort, but with all which the most refined luxury has been able to suggest. "Merchandise," to use the words of Scripture, "of gold, and silver, and precious stones, and of pearls, and fine linen, and purple, and silk, and scarlet, and all thyine wood, and all manner vessels of ivory, and all manner vessels of most precious wood, and of brass, and iron, and marble, and cinnamon, and odours, and ointments, and frankincense, and wine, and oil, and fine flour, and wheat, and beasts, and sheep, and horses, and chariots."

But the importance of all the foregoing points of consideration in the history of the relation of the air to human wants is far inferior to that highest and most beneficial of all its relations, the production of the human voice: for from this source arises articulate language; without which medium of communication between man and man, what would become of the most important transactions of the business of life, as well as of its most rational pleasures, the charms of social converse? But the consideration of the mechanism of the human voice is appropriated to a distinct treatise: and the use of language is adapted rather to the moral than to the physical condition of man: and I therefore forbear to dwell on a theme in itself of the highest interest.

In dismissing the subject of atmospherical air, I would wish to observe how beautiful an instance its history affords of the multiplicity of beneficial effects, of very different characters, produced by one and the same agent; and often at one and the same moment. Thus while we have seen the air of the atmosphere serving as the reservoir of that mass of water from whence clouds of rain, and consequently springs and rivers are derived, we have also seen that it at the same time prevents, by the effect of its pressure on their surface, the unlimited evaporation and consequent exhaustion of the ocean, and other sources, from whence that mass of water is supplied. And, again, while the agitation of the air contributes to the health of man, by supplying those currents which remove or prevent the accumulation of local impurities, it at the same time facilitates that intercourse between different nations in which the welfare of the whole world is ultimately concerned. And lastly, while in passing from the lungs in the act of expiration it essentially forms the voice, it at the same time removes from the system that noxious principle, the retention of which would be incompatible with life.

CHAPTER VII.

ADAPTATION OF MINERALS TO THE PHYSICAL CONDITION OF MAN.

Section I.

The general Characters of Minerals.

It has been shown in the foregoing chapter, that the constituent parts of the atmosphere are few in number, and of great simplicity in their composition; that some of them usually exist in the state of invisible vapour, and consequently are without sensible form and colour: and that others, as light, and heat, and electricity, are not only without form and colour, but are also of such tenuity as to be incapable of affecting the most delicately constructed balance; in common language, are without weight. We are now entering on a department of nature, which consists of objects characterised by properties very different from those we have been lately considering; remarkable, as a class, for the mathematical precision of their form, the brilliancy and variety of their colour, and for their great weight; most of them being many times heavier than the heaviest element of the atmosphere.

Few mineral substances, however, exist in such a state of purity as to exhibit the simple characters of their individual properties; the class consisting of a great variety of species, which are capable of entering into union with each other, and of which the natural combinations are extremely numerous. But, as might be anticipated from the general analogy of nature, the advantages arising to mankind from this mixture of character are infinitely greater than if the individual minerals had existed in a state of purity, and uncombined with each other. Thus, to take the most familiar, and perhaps the most important instance, almost all natural soils consist principally of mixtures of the three earths called *silex*, *lime*, and *alumine;* none of which, unmixed with either of the other two, or at least, with some equivalent substance, would serve the purposes of agriculture.

Again, all the common forms of clay consist principally of various combinations of the two earths called *silex* and *alumine;* and although many of those properties which make clay valuable are communicated by the alumine, the silex contributes very considerably towards the general utility of the compound.

SECTION II.

Application of Minerals to Architecture and Sculpture.

AMONG the earliest arts of civilized life may be justly reckoned the rudiments of architecture: for it may be with truth affirmed that, with very few exceptions, wherever man exists in a state of society, he is found to protect himself from the vicissitudes of the weather, not only by the immediate clothing of his body, but by means of independent habitations; to which, if at no other time, at the close of the day at least, he betakes himself; in order to enjoy that periodical rest which is requisite for the renewed exertion of his bodily powers: and very few are the situations which do not afford convenient materials for the purposes of building.

In whatever situation then man may be placed, he will most probably have the means of procuring the comfort of a fixed habitation. Nor is it long before he adds a certain degree of luxury to utility: for wherever the simple architecture of the dwelling is not decorated with some ornamental additions, we may be certain that society exists in a very low state of civilization; so that sculpture, as an artificial refinement, seems to be a natural consequence of architecture. And, perhaps, the superiority attainable by education and habit is not displayed in any of the arts of life so strikingly as in these. From the simple tent of the Bedouin to the majestic ruins of Palmyra, among which it is pitched; or from the rude hut of the modern Acropolis to the awful grandeur of the Parthenon which overshadows it; how infinite are the gradations which mark the progress of these arts!

And with respect to statuary, that highest department of the art of sculpture, what emotions is it not capable of raising in the mind, particularly when employed in representing the passions or any of the attributes of man! If, for instance, the mind of the savage could be instantaneously elevated to the feeling of correct taste, what would be the sensations of the islander of the southern Pacific, in turning from the view of his hideously-formed and grim idol, to the contemplation of that glory of the Vatican,

——— "The Lord of the unerring bow,
The God of life, and poesy and light;
The sun in human limbs arrayed, and brow
All-radiant from his triumph in the fight:
——— in whose eye
And nostril, beautiful disdain, and might,
And majesty, flash their full lightnings by,
Developing in that one glance the Deity."*

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* Childe Harold, canto IV. stanza 161.

I will not here attempt to trace the history of architecture, considered as an art characteristic of civilized society: for in such an attempt our reasoning must often be founded on conjecture instead of facts; than which nothing is more unsatisfactory and irksome to a philosophically contemplative mind. It will be more congenial to the purpose of this treatise to point out the means afforded by nature for the advancement of an art, which in its origin is necessary to some of the chief wants and comforts of individuals; and which is subsequently conducive, by the exercise of the highest faculties of the mind, not only to national utility and glory, but also to national security.*

With respect to the inferior animals, the instinctive propensity to construct receptacles for themselves or their offspring is obvious: and if on any ground we may attribute the principle of instinct to man, it seems justifiable on that which we are now considering. Omitting, however, those more remarkable instances of instinct which direct the bee, the ant, the spider, the swallow, or the beaver, in the fabrication of the structures which they put together with such nice art; if we merely consider the simple burrow of the rabbit or the mole, we seem to acquire a strong presumption, that man would not be destitute of a similar instinct: and it may reasonably be supposed that, by whatever intellectual power or internal sensation the savage is directed so to adjust the various joints and muscles of his limbs as to balance his body when in danger of falling, by a similar power he is enabled so to adjust the rude boughs of which his hut is composed, that by mutually supporting one another they may at the same time serve for a support to the grass, or moss, which is thrown over them for the purpose of forming a shelter.† Numerous traces of such an instinct are observable in the amusements of children; as in the arrangement of loose stones in the form of enclosures; and in the formation of banks and dikes by the heaping up of the sand of the sea-beach: and, should it be asserted that such amusements are not to be referred to instinct, but are to be classed simply under the principle of imitation, (as may certainly many of the amusements of children,) it may be answered, that, if not original instincts, they may be considered as at least instinctive imitations of the necessary engagements of after-life. It has been sometimes supposed that the inclining branches of an avenue of elms or other trees suggested the idea of the gothic aisle; but such a supposition seems both unnecessary in itself, and incorrect as to the probable order of occurrences: for whoever has read the travels of Pallas through different parts of the Russian empire, or of other Oriental travellers, will find ample proof of the existence of the gothic style of architecture long before our earliest European churches were built: and it is just as probable, if not more so, that the gothic aisle suggested the idea of the elm avenue, as that this suggested the idea of the gothic aisle.

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* In the construction for instance of military fortifications, and piers, and bridges, &c.

† The following statement, from Lewis and Clarke's Travels, will show how much may be effected by human ingenuity and industry though aided by the slightest means: "The Columbian Indians possess very few axes; and the only tool employed in their building, from the felling of the tree to the delicate workmanship of the images, (adorning their canoes,) is a chisel made of an old file: and this is worked without the aid of a mallet. But with this, they finish a canoe fifty feet long, and capable of holding between twenty and thirty persons, in a few weeks." p. 435. To the preceding statement may with propriety be added the following translation of the account which accompanies the twelfth plate in the first volume of De Bry: "The method of making boats in Virginia is truly wonderful: for, although the natives have no instruments of iron, or in any way resembling those of European nations, they still have the power of making boats fully capable of being conveniently navigated. Having selected a large and lofty tree, they surround it with a fire just above the roots; taking care to smother any flame, lest it should injure the rising part of the stem. In this way they burn through the greater part of the stem; and, by thus weakening it, occasion its downfall. By a similar process they burn away the branches and the upper part of the tree; and, raising the trunk thus prepared on forked props, so as to support it at a convenient height for working, they scrape away the bark by means of large shells; and then excavate it in a longitudinal direction by alternately burning and scraping it."

The mineral substances employed in the structure of human habitations necessarily differ in different parts of the world, in consequence of the difference of the materials afforded by the subjacent strata; and, accordingly, an experienced eye will conjecture, almost with certainty, the character of the subjacent strata, from the nature of the materials employed in the buildings erected on the surface: or, conversely, if the nature of the subjacent strata be antecedently known, the character of the stone employed in the buildings of the vicinity will, almost to a certainty, be known also; and, on this principle, as much surprise would be excited in the mind of a well-informed geologist by the prevalence of granite in the buildings of Kent or Sussex, as of limestone near the Land's End in Cornwall.

The nature, however, of the material employed in building is in some measure determined by the particular stage of civilization of the inhabitants. Thus in the early periods of civilization, and before the aboriginal forests of a country have been cleared, wood has usually been the principal and almost the only substance employed. In proportion as the population of a country increases, wood becomes more and more scarce; and then brick and stone begin to be employed: but when the population has increased to a very considerable extent, those materials almost entirely supersede the use of wood, unless in the interior of the building: and hence, in this densely-peopled island, the half-timbered dwellings of our ancestors are daily becoming more picturesque*

The value of building-stone depending greatly on its hardness, but the difficulty of working it being increased proportionally to its degree of hardness, it ought not to escape our notice, in a treatise, of which it is the professed object to illustrate the adaptation of external nature to the physical condition of man, that many of the common forms of building-stone, though soft while yet undetached from the quarry, become hardened very considerably by exposure to the air: which change in their state enhances their value in a twofold sense; for, in consequence of their previous softness, they are more easily worked; while their subsequent hardness insures the greater durability of the building in which they are employed. And, again, though many varieties of stone are so easily worked, even after a long exposure to the air, as to have acquired in consequence the name of *freestone;* yet even with respect to such as are of the hardest and toughest quality, an equal degree of ease in working them is easily attainable by practice. To an unpractised workman, for instance, nothing is more difficult than to give a determinate form, by the hammer or chisel, to granite, slate, or flint; and yet a little experience enables the mason to work all these to the greatest nicety: and that person would indeed be very incurious, who, although he might not naturally be disposed to notice mechanical processes, did not feel an interest in observing the form which the roofing-slate takes under the bill of the slater; or the ease with which the gun-flint is formed into its peculiar shape by a few strokes of a light hammer.

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* Throughout the interior of Russia and of Siberia the greater part of the buildings in every town were, within a few years, entirely of wood.

But, after the stones have been detached from the quarry, and have been worked into a convenient form for building, it is in the greater number of instances necessary to the stability of the intended structure, that they should be consolidated together by some intermediate substance: for it would very rarely happen that the separate stones could be obtained of such a size as to be capable of remaining fixed by their own weight. Sometimes this effect is produced by means merely mechanical, as in the case of the construction of the larger circle of Stonehenge; where the upper extremity of two contiguous perpendicular stones, being pared away so as to form what is called a *tenon*, is let into a corresponding cavity called a *mortise* cut into each extremity of the horizontal stone that unites them.

As such Cyclopean masonry would be far too expensive for common purposes; and as the labour and expense of uniting together, by cramps of iron or other mechanical means, the very great number of stones requisite for the construction of even a small building, would be endless; we at once see the importance of any medium that will fully and readily effect that union, without much expense of time or money: and how completely the substance called *mortar* answers the intended purpose, the slightest observation will make manifest. As the employment of this useful substance appears to have existed antecedently to history, it is not worth while to spend any time in conjecturing how it was first discovered: but it is quite in unison with the intention of the present treatise to observe, that, of the three materials of which it is principally made, namely lime, sand, and water, the first is readily obtained by the simple application of heat to any common form of limestone, a process which is occasionally going on in every limekiln; and the means of obtaining the two others are almost every where at hand.

Hitherto the materials, applicable to the arts of architecture and sculpture, have been considered as adapted to the common or necessary wants of mankind: but in what may not improperly be called the poetry of those arts, they are capable, in their application, of eliciting the highest powers of the imagination: for surely this may with propriety be affirmed of such sublime productions as the Parthenon in architecture, or the Belvedere Apollo in sculpture. Nor are we obliged to seek for such productions solely in the classic ages of antiquity: for, to say nothing of Palladio, Michael Angelo, Canova, Thorvaldson, and other ornaments of modern Europe, our own country has given birth to works of the highest excellence in either department of the art. Nor need this assertion be made with any hesitation, while in architecture that imperishable monument of genius, the Eddystone lighthouse, attests the fame of Smeaton; and in sculpture, the pure and simple taste of Chantrey has, in that most exquisite work contained within the walls of Litchfield cathedral, thrown a truth and beauty over the image of death, which none of his predecessors had ever attained.*

Who can peruse the journal of Smeaton, and not admire the penetration, the resources, and the activity of his genius? Consider the nature of the task which he had engaged to perform; his limited and uncertain opportunities of action; the failures of others who had preceded him in a similar undertaking; the consequent necessity of new principles, and new combinations, in his plan of operations; the formidable dangers he was continually under the necessity of encountering; and, lastly, the awful responsibility of the undertaking itself: consider all these points, and it may be safely affirmed that, as an instance of the conjoined effects of personal enterprise, fortitude, and perseverance, the Eddystone lighthouse stands unrivalled.

On a small, precipitous, and completely insulated rock, deriving its very name from the irregular and impetuous eddies which prevail around it; elevated but a few feet above the level of the surrounding ocean, even in its calmest state; and exposed at all times to the uninterrupted swell of the Atlantic; by the joint violence of the wind and waves of which, a preceding structure had been in a moment swept away, leaving not a wreck behind; on such a spot was this new wonder of the world to be erected. Former experience is here of little avail, and common principles and means have been already tried in vain; the architect is thrown almost entirely on his own resources; and they do not fail him. In order to combat the force of those overpowering elements to which the future structure is to be constantly exposed, he looks about for that *natural* form which is found most permanently to resist a similar conflict; and viewing with a philosophic eye the expanded base of the oak, and the varying proportions of its rising stem, he made the happy selection of this object as the type of the proportions of his intended work.

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* One exception to this assertion perhaps exists, in a work on a similar subject by Banks; in the church of Ashbourne, Derbyshire.

"On this occasion," he himself says,* "the natural figure of the waist or bole of a large spreading oak presented itself to my imagination. Let us for a moment consider this tree: suppose at twelve or fifteen feet above its base, it branches out in every direction, and forms a large bushy top, as we often observe. This top, when full of leaves, is subject to a very great impulse from the agitation of violent winds; yet partly by its elasticity, and partly by the natural strength arising from its figure, it resists them all, even for ages, till the gradual decay of the material diminishes the coherence of the parts, and they suffer piecemeal by the violence of the storm: but it is very rare that we hear of such a tree being torn up by the roots. Let us now consider its particular figure—connected with its roots, which lie hid below ground, it rises from the surface thereof with a large swelling base, which at the height of one diameter is generally reduced by an elegant curve, concave to the eye, to a diameter less by at least one third, and sometimes to half of its original base. From thence its taper diminishing more slow, its sides by degrees come into a perpendicular, and for some height form a cylinder.

"After that, a preparation of more circumference becomes necessary for the strong insertion and establishment of the principal boughs, which produces a swelling of its diameter. Now we can hardly doubt but that every section of the tree is nearly of an equal strength in proportion to what it has to resist: and were we to lop off its principal boughs, and expose it in that state to a rapid current of water, we should find it as much capable of resisting the action of the heavier fluid, when divested of the greatest part of its clothing, as it was that of the lighter when all its spreading ornaments were exposed to the fury of the winds: and hence we may derive an idea of what the *shape* of a column of the greatest stability ought to be, to resist the action of external violence, when the *quantity* of matter is given whereof it is to be composed."

But invention and composition, do not constitute the whole of the character of genius, in the practical arts at least. Industry, both that which resists the listlessness arising from continuity and sameness of pursuit; and, still more, that which, though repeatedly repressed by unexpected impediments, as repeatedly recovers its elasticity; unconquerable and indefatigable industry, like that of the ant, is likewise requisite. And such industry did Smeaton manifest: and his industry has hitherto been completely crowned with success. The Eddystone has withstood the war of winds and waves through the greater part of a century, unshaken in a single point: and if of any human work we dare affirm as much, we might affirm of this, "manet æternumque manebit."

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* A Narration of the Building, &c. of the Eddystone Light-house, London, 1791, p. 42.

We now turn to the efforts of genius, of another, and, intrinsically, a higher order—to that beautiful composition of Chantrey, to which allusion has been already made. A different task is here to be accomplished: it is not the storm of the physical elements which is to be resisted, but the poignant grief of the bereaved parent is to be assuaged; and that, not by any *nepenthe* which may obliterate the memory of lost happiness; but by, I had almost said, the living image of the very objects themselves from which that happiness arose, and in which it centred. Alone, and undistracted by the presence of surrounding friends, the widowed mother approaches in mournful silence the consecrated aisle; where, softly clasped in each other's arms, she sees her beloved children resting in the repose of sleep rather than of death: and gazing on them with intense affection, she feels not sorrow for a while; but, indulging in a dream which almost realizes her past happiness, would fold her treasures to her bosom, were she not too conscious that the cold embrace would dissipate the fond illusion.

Section III.

Gems and Precious Stones.

If it were the purpose of this treatise to point out the adaptation of external nature to the moral as well as to the physical condition of man, it might be easily shown, that, however an undue degree of attention to outward ornaments is blameable, a moderate degree of attention is both allowable and right: otherwise, and it is an instance that outweighs all others, it would not have been observed in the decorations of the temple of Solomon, nor in the original ordinations respecting the dress of the Levitical priesthood. Those substances consequently, which are capable of being applied to ornamental purposes, become, in our mode of using them, a test of virtue, in the same manner as our ordinary clothing, and food, and sleep; all of which, though even necessary to our existence, may be abused by a luxurious indulgence in them. But at present I am no further concerned with the moral part of the question, than to infer that, if an attention to external ornament be not only allowable, but right, we may antecedently expect that materials for its exercise would be provided by nature: and that is indeed the fact.*

It would be difficult however to determine, which of the three kingdoms, the animal, vegetable, or mineral, is the most prolific source of those beautiful forms and colours which are principally valued as objects of external ornament. We do not indeed observe in any flower that iridescent play of colours which characterises some varieties of the opal and felspar, among minerals; and the plumage of certain birds and the scales of certain fish, among animals: but in elegance and variety of form, and in splendour and simplicity of colour, the vegetable world will be found to yield neither to the animal nor mineral. Mineral substances, however, from their rarity as well as beauty, are more prized; and from the durability of their substance are more permanently applicable to ornamental purposes than those either of animal or vegetable origin; and therefore serve better to illustrate the principle of this treatise.

From among those substances which in commercial language are called precious stones, though some so called are not really derived from the mineral kingdom, it is proposed to select the diamond as a pre-eminent example of the whole class; because, in addition to those properties which render it valuable as an ornamental gem, there are some points in its history which give it a peculiar worth. It will naturally excite the surprise of those, who are unacquainted with the chemical history of this substance, to learn that the purest diamond does not essentially differ from a particular variety of common coal; or from that mineral of which drawing pencils are made, and which is usually, though not with propriety, called *plumbago* and *black lead:* and yet nothing has been more clearly proved than that equal weights of these several substances, if submitted to the process of combustion, will produce nearly equal proportions of carbonic acid gas; which has already been stated to be a chemical combination of definite proportions of carbon and oxygen; the diamond, which is the purest form of carbon, burning away without leaving any residuum; the other two leaving a very small proportion of ashes, in consequence of their containing foreign matter.

And here we can hardly fail to notice a very remarkable instance of what may be called the economical provisions of nature. How rarely, and in what small quantities, are the diamond and plumbago found; and how abundantly does coal predominate in many parts of the world! The Borrodale mine of plumbago in Cumberland is the most considerable source of that substance throughout Europe; and the province of Golconda almost alone supplies the whole world with diamonds: and, probably, the accumulated weight of all the plumbago and of all the diamonds which have ever been derived from those and other sources, would not equal a hundredth part of the weight of coal which is daily quarried in Great Britain. Suppose now that the case had been reversed; and what would have been the consequence! diamond and plumbago, though really combustible substances, yet from their slow combustibility could never have answered, in the place of coal, as a fuel for general purposes; and, on the other hand, without that large supply of coal which nature has provided, what would have become of the domestic comforts and commercial speculations of the greater part of Europe, during the two last centuries?

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* "Wherefore did nature pour her bounties forth?" &c.
COMUS, line 726, &c.

The value of the diamond is not derived solely from its transparency and lustre. Its remarkable hardness is another and a most useful property belonging to it: for, in consequence of its great degree of hardness, it is capable of cutting and polishing not only the hardest glass, but even the hardest gems: and if we consider how usuful a substance glass is, how universally employed as a means of at the same time admitting light and excluding the air from the interior of our houses; but that in consequence of its hardness and brittleness it would with great difficulty be divided by any common mechanical instrument, so as accurately to fit the frames in which it is fixed for the above purposes, we at once see the value of a substance which easily and readily accomplishes that end. A small diamond no larger than a mustard seed, brought to a point and fixed in a convenient handle, enables the glazier to cut a plate of glass into pieces of any shape that he pleases: and the same instrument will serve his daily use for many successive years. Nor is it among the least of the glories of this gem, that it gave occasion to that remarkable conjecture of Sir Isaac Newton respecting its chemical nature. That philosopher having observed, that the refractive power of transparent substances is in general proportional to their density; but that, of substances of equal density, those which are combustible possess the refractive power in a higher degree than those which are not, concluded from a comparison of the density and refractive power of the diamond, that it contained an inflammable principle; which opinion was subsequently confirmed by direct experiment. It will be remembered by the chemical reader that on the same ground he made the same conjecture with respect to water, and with the same success. And never, perhaps, did the eye of philosophy penetrate more unexpectedly the thick veil which is so often found to hide the real character of various forms of matter: for, imperishable as from its name the *adamant* was supposed to be, who would have antecedently expected that it might be dissipated into air by the process of combustion? and, with respect to the other subject of his conjecture, if any principle was opposed to combustibility in the opinion of mankind it was water—“ Aquæ contrarius ignis.”

Section IV.

The Distribution and relative Proportions of Sea and Land; and the geological Arrangement and physical Character of some of the superficial Strata of the Earth.

As it is clearly a just object of the present treatise to select the most familiar and most obvious instances of the principle intended to be illustrated, I shall in entering upon the abstruse department of geology, consider only those phenomena which offer themselves to the eye in every part of the world; and which are either at once intelligible, or easily demonstrable, to the commonest observer.

Of such phenomena the most prominent are the general distribution of the sea and the land; and the relative proportions of their superficial extent. With reference to the sea, although we may never know all the ends which are answered by its saltness, and why its depth should be greater in some parts than others; and although we can perhaps form no more than a conjecture as to the advantages derivable from the tides; (the prevention, for instance, of a stagnant state of the water;) or from the accumulation of ice near the poles; (the cooling, probably, of the general mass of the atmosphere, and the consequent production of currents of air;) yet of its mode of distribution, and of the relative extent of its surface, we readily apprehend the reason; simply in considering that all those forms of water which contribute to the fertilization of the earth, or the support of animal life, are derived from the ocean. Were the superficial extent of this therefore much less than it is, the quantity evaporated would not be sufficient for the intended purposes; or, were the distribution different from what it is, were the sea, for instance, to occupy one hemisphere, and the land the other, the water evaporated would not be so equally diffused through the atmosphere as it is at present.

And, with respect to the land, how beautifully does the particular arrangement and character of its surface conspire with its general distribution, to equalize the diffusion of the water that is discharged upon it from the atmosphere! The truth of the proposition contained in those lines,

> "Rusticus expectat dum defluat amnis, at ille
> Labitur, et labetur in omne volubilis ævum,"

depends on the nature of the particular arrangement and character, to which allusion has just been made. On the one hand, the general surface of the land ascending from the sea on all sides towards some central ridge or district, called the watershed of the country, all the rain that does not sink beneath the surface is accumulated into rivers;

which naturally descend towards, and ultimately reach, the sea: and, on the other hand, the superficial strata being in general incapable of immediately absorbing the rain which falls upon them, the descent of the water is the necessary result of the inclination of the surface. But if, from partial causes, such an inclination of the land is either wanting, or the course of rivers is impeded by the unrepressed growth of reeds and sedge, the adjoining district is overflowed, and at length converted into a stagnant marsh. It is from such a *physical* cause, that, at this moment, the ancient site of Babylon attests the truth of prophecy; being still, as it has been for ages, "a possession for the bittern, and pools of water."

But that which is called the watershed of any large tract of land is not simply the most elevated portion of the whole surface: it consists also, in a greater or less degree, of ranges of mountains; down the high inclined sides of which the rain immediately descends in numerous torrents, which by their gradual accumulation produce rivers. And, as best calculated to secure the permanent effect, the substance of these mountains is in general so hard, and impermeable to water, that, with reference to the present system of the earth, they may justly be characterised by the epithet "everlasting." But if, instead of being thus durable, they were of a soft or friable substance, they would soon cease to exist as mountains; and if they were porous, instead of compact, they would absorb much of that rain which now contributes to the formation of rivers.

From that portion of the rain which, in comparatively flat districts, sinks beneath the surface of the earth, reservoirs of water are formed: from which, either spontaneous springs arise, or into which, artificial excavations called *wells* are sunk: and of the utility of such reservoirs, those beds of gravel which occur in every part of the world afford upon the whole the best illustration.

Section V.

Beds of Gravel.

Few subjects would at the first view appear more barren of interest than a bed of gravel; consisting, as it usually does, of nothing but fragments of broken pebbles and sand, heaped together in apparently inextricable confusion. Yet such beds, dispersed as they are very generally over the surface of the regular strata, administer materially to the wants of man; in affording him the means of supplying himself readily with that important necessary of life, water.

From the irregularity in the form and size of the component parts of gravel, and from the slight degree of cohesion by which they are united, the whole mass is necessarily porous: and hence, readily transmiting the rain which falls on its surface, becomes charged with water to an extent proportional to the quantity of rain which has penetrated it; being enabled to retain the water thus accumulated, in consequence of its resting on some substratum, as clay, which is impermeable to water: so that, if an excavation sufficiently deep be made into any part of the gravel, the water immediately drains into this excavation, and rises at length to the level of the general mass of water contained in the whole bed; by which easy process, in such instances at least, those reservoirs, called wells, are formed: and these reservoirs are never exhausted, so long as the whole bed of gravel retains any considerable proportion of water. A very ready illustration of this fact is afforded by the familiar instance of those excavations which children are accustomed to make in the sand of the sea-beach, while yet charged with moisture during the ebbing of the tide.

The inhabitants of a town which, like Oxford, is built partly on a comparatively shallow bed of gravel, and partly on a deep stratum of clay, can well appreciate the value of the former substratum of their habitations, with reference to the facility of procuring water: for while they, whose dwellings are built on the gravel, can readily obtain water by sinking a well immediately on the spot; they whose dwellings are on the clay, must either procure water from a distance, or incur a very serious, and, finally perhaps, useless expense, in attempting to penetrate the clay.* With respect to its general uses, gravel seems only to be employed in the repairing of roads and walks; in the composition of some kinds of mortar; and as a convenient occasional ballast for sailing vessels: so that, if we confine our view to the means afforded by gravel beds of supplying the ordinary wants of man, their history may be comprised in a few words. Not so, if we view them with reference to their origin, and the nature of their occasional contents: and little dreams any one, save the professed geologist, what a mine lies hid, in those confused heaps of ruin, for the exercise of man's intellectual faculties. Few subjects indeed have afforded ampler scope for philosophical reflection. In proof of which I need do no more than refer to the labours and ingenuity of Cuvier on the continent, and of Professor Buckland in our own country: of whom the one, by a scientific examination of the organic remains of gravel beds, in addition to those of some of the regular strata, has brought to light not only numerous individual species, but whole families of animals, which have ceased to exist ages and ages since: and the other, with no less labour and ingenuity, has all but exhibited some of these animals to our view in the very act of devouring and digesting their food.

How often, and with what intense interest, has not the scientific geologist perused the original essays of Cuvier; in which, setting out from the casual observation of a simple fragment of a fossil bone belonging to some extinct species, he has established not only the class and order, but even the size and proportions of the individual to which it belonged, and the general nature of its food. And how often, in addition to professed geologists, has not an attentive audience of academical students listened with admiration to the clear and vivid eloquence of the other of those philosophers, the Geological Professor of Oxford, while he unfolded that beautiful chain of facts by which he traced his antediluvian animals to their native caves; and exposed to view, to the mental eye at least, and almost to the corporeal, their particular habits, and even the relics of their last meal. And, lest there should be any doubt as to the nature of this meal, he discovered, by a most philosophical, for I will not say fortunate conjecture, unequivocal proofs of the actual remains of it; not only in its original, but also in its digested state. I here allude particularly to his verifications of the masses of digested bone which he has most satisfactorily shown to have passed through the whole tract of the digestive organs of his favourite hyenas; and which are so nearly identical, in every character, with the similar masses that daily traverse the same organs of the living species, as to make it difficult even for an experienced eye to ascertain the difference between them.

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* From the observation of analogous arrangement in the general strata of the earth, namely, that those which are pervious to water alternate with those which are impervious to water, Mr. William Smith, "the father of English geology," became acquainted with the origin of springs, and the true principles of draining.

It is natural that I should feel a pleasure in recording the well-earned fame of a friend with whom I have lived in habits of intimacy for more than twenty years; and whom, in the commencement of his career, I had the good fortune to lead into that avenue of science, on which he has subsequently thrown more light than perhaps any other English geologist; with the exception indeed of one, the reverend W. Conybeare, the admiration of whose comprehensive and commanding views, as well in fossil as in general geology, is not confined to his own countrymen; the members of the French Institute having attested their sense of his pre-eminent talents by the high honour of selecting him, a few years since, as one of their foreign associates—an honour particularly distinguished by the uncommon circumstance, that it was not only unsolicited, but unexpected, by himself.

On one point, however, of Professor Buckland's general theory of the organic remains met with in gravel beds, and in certain natural caverns, I not only differ from him, but think it right to express the ground of that difference. Dr. Buckland's arguments in favour of his opinion that the animals of the gravel beds, and the caverns, habitually frequented the spots where these remains are found, are not only ingenious, but are occasionally supported by facts which almost necessarily lead to that conclusion: and it is not intended to attempt to invalidate them. They do not indeed stand in the way of the objection now to be advanced: this objection being applicable to that part of theory only which considers the destruction of these animals as the effect of the Mosaic deluge. Nor is the objection, in its origin, so much directed against the insulated supposition that these organic remains are immediate proofs of the Mosaic deluge; as against the *principle* of supporting the credibility of the sacred Scriptures on any unascertained interpretation of physical phenomena. Such a support appears to be imprudent, as well as unnecessary: uunecessary, because the moral evidence of the credibility of the Scriptures is of itself fully sufficient; imprudent, because we have the strong ground of antecedent analogy, not only in another but in this very branch of knowledge, for anticipating a period in the progress of science, when particular phenomena may be interpreted in a very different manner from that in which they are intepreted at present. Thus the explanation of the motions of our solar system, which is now admitted very generally, without any fear of weakening the authority of Scripture, was once as generally impugned on the principle of that very fear. Time was also, and indeed within the last century, when the shells and other organic remains, which are imbedded in the chalk and other solid strata, were considered to be the remains and proofs of the Mosaic deluge; and yet at the present day, without any fear of injuring the credibility of the Scriptures, they are admitted very generally to have been deposited anteriorly to the Mosaic deluge. And who will venture to say, in the infancy of a science like geology, that the same change of opinion may not happen with respect to the organic remains of the gravel beds and caverns. Nor indeed do I think, and I expressed this opinion nearly twenty years since, that the organic remains of the gravel beds and the caverns can be, on even mere philosophical grounds, adduced as physical proofs of the Mosaic deluge. For as according to the Mosaic record it was the intention of the Deity on that occasion, in the midst of a very general destruction of *individuals* to preserve *species*, we should in reason expect, among the organic remains of that catastrophe, a preponderance, at least, of the remains of existing species: since, although some species may have been lost subsequently to the deluge, these naturally would be comparatively few. But the fact is just the reverse; for by far the greater number of the organic remains of the gravel, as of the caverns, belong to species not known now to exist. And with respect to those remains which appear capable of being identified with living species, Cuvier allows that they belong to orders of animals, the species of which often differ only in coulor, or in other points of what may be called their external or superficial anatomy; and cannot therefore be satisfactorily identified by the remains of their bones alone.

I do not consider it right to enter into a more extended examination of the question on the present occasion: but, could it be proved that *visible* traces of the Mosaic deluge must necessarily exist, arguments might be adduced to show both where those traces ought to be expected, and that they do actually exist. But the deluge itself was evidently a miracle, or an interference with the laws which usually regulate the operation of second causes: and whoever admits the force of the reasoning, contained in Butler's Analogy of Natural and Revealed Religion, will be disposed to allow that *visible* evidence of the catastrophe may have been purposely obscured, in order to exercise our faith in an exclusive belief of the *moral* evidence.

I would not lay undue weight on the negative proof arising from the absence of human remains, although they have been in vain searched for, even in parts of the world to which it may fairly be presumed that the human race had penetrated at the period of the Mosaic deluge: but undoubtedly such a negative proof is not without considerable weight; especially when taken in connexion with the theory of a continental geologist, M. de Beaumont, of whose powers of philosophical generalization Professor Sedgwick speaks in language the most expressive. "I am using," he say, "no terms of exaggeration, when I say that, in reading the admirable researches of M. de Beaumont, I appeared to myself, page after page, to be acquiring a new geological sense, and a new faculty of induction."*

After having taken a general survey of M. de Beaumont's observations and views, Mr. Sedgwick alludes to an opinion which he himself had expressed in the preceding year, that what is commonly called diluvial gravel is probably not the result of one but of many successive periods. "But what I then stated," he adds, "as a probable opinion, may, after the essays of M. de Beaumont, be now advanced with all the authority of established truth—we now connect the gravel of the plains with the elevation of the nearest system of mountains; we believe that the Scandinavian boulders in the north of Germany are of an older date than the diluvium of the Danube: and we can prove that the great erratic blocks, derived from the granite of Mont Blanc, are of a more recent origin than the old gravel in the tributary valleys of the Rhone. That these statements militate against opinions, but a few years since held almost universally among us, cannot be denied. But, in retreating when we have advanced too far, there is neither compromise of dignity, nor loss of strength; for in doing this, we partake but of the common fortune of every one who enters on a field of investigation like our own. All the noble generalizations of Cuvier, and all the beautiful discoveries of Buckland, as far as they are the results of fair induction, will ever remain unshaken by the progress of discovery. It is only to theoretical opinions that my remarks have any application." (p. 33.)

Mr. Sedgwick then proceeds to argue that different gravel beds having been formed at different periods, it may happen from the nature of diluvial action, that mixtures of the materials of different beds may occur; and consequently that "in the very same deposite we may find the remains of animals which have lived during different epochs in the history of the earth." (p. 33.)

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* See Prof. Sedgwick's address to the Geolog. Society, 1831, p. 29.

He then shows how, from the double testimony of the widely existing traces of diluvial action, and the record of a general deluge contained in the sacred Scriptures, the opinion was naturally formed that all those traces were referable to one and the same action: though we ought in philosophical caution to have hesitated in adopting that opinion, because "among the remnants of a former world, entombed in these ancient deposites, we have not yet found a single trace of man, or of the works of his hands." (p. 34.) Lastly, he strenuously denies that the facts of geological science are opposed to the sacred records, or to the reality of an historic deluge; and for himself, utterly rejects such an inference: and argues justly, that there is an accordance between the absence of human remains in these diluvial beds of gravel, and the supposed antiquity of their formation, inasmuch as the phenomena of geology, and the testimony of both sacred and profane history, "tell us in a language easily understood, though written in far different characters, that man is a recent sojourner on the surface of the earth." (p. 35.)

Section VI.

Metals.

The atmosphere, and the vegetable, and animal kingdoms, being three out of the four general departments of the external world, are most extensively necessary to the welfare, if not to the very existence, of every individual: but even communities of men, in an uncivilized state indeed, have existed, and in some parts of the earth are still existing, without any further aid from the mineral kingdom than that, which the common soil affords to the growth of the food which supports them. But a civilized state of society is the natural destination of man; and such a state of society is incapable of arising or being maintained, without the aid of mineral substances: and this assertion holds more particularly with respect to the *metallic* species.

In that department of civilized intercourse which exists in the exchange of the commodities of life, what other substance could be an equivalent substitute for gold and silver, or even copper, as a medium of that exchange? In what constant use, and of what immense importance, are some of the commonest metals in agriculture, and in the arts; or for the various purposes of domestic life! Nor have any substances more successfully exercised the powers of the mind, in the discovery or improvement of physical truths; or more largely contributed to the benefit of mankind by the practical application of those truths. We owe it to the researches of philosophy, not only that new and highly valuable metals have been discovered; but that the general value of the metals previously known, has been advanced by extended and improved applications of their inherent properties, or by the invention of new metallic combinations or alloys.

If a convincing and familiar proof of the extensive application of the metals to the common purposes of life were required, we need only refer to the case of many a common cottager, who could not carry on his daily concerns and occupations without the assistance of several of the metals. He could not, for instance, make his larger purchases, nor pay his rent, without silver, gold, and copper. Without iron he could neither dig, nor plough, nor reap; and, with respect to his habitation, there is scarcely a part of the structure itself, or of the furniture contained in it, which is not held together, to a greater or less extent, by means of the same metal: and many articles are either entirely of iron, or of iron partially and superficially coated with tin. Zinc, and copper, and antimony, and lead, and tin, are component parts of his pewter and brazen utensils. Quicksilver is a main ingredient in the metallic coating of his humble mirror: cobalt and platina, and metals perhaps more rare and costly than these, as chrome, are employed in the glazing of his drinking cups and jugs. And if he be the possessor of a fowling-piece, which commonly he would be, arsenic must be added to the foregoing list, as an ingredient in the shot with which he charges it; for it is arsenic which enables the shot, during the process of its granulation, to acquire that delicately spherical form by which it is characterised. So that the whole number of metals made use of by society at large for common purposes, amounting to less than twenty, more than half of these are either directly used by the mere peasant, or enter into the composition of the furniture and implements employed by him.

In estimating the value of those mineral substances which were considered in the preceding chapter, as applicable to the common purposes of life, their degree of hardness is the property of principal consideration: but, in addition to this, metallic bodies possess some peculiar properties which very greatly increase their value. Thus, under a force acting perpendicularly on their surface, as under repeated blows of the hammer, or compression by rollers, many of them are capable of being expanded to a greater or less extent; some of them to such an extent as to become thinner than the thinnest paper; which property in its various degrees is expressed by the term *malleability:* others, though not possessing any great degree of malleability, may be drawn out into a wire, sometimes so fine as scarcely to be visible by the naked eye; which property is expressed by the term *ductility*. All of them are capable of being expanded or contracted in every direction by an increase or decrease of their temperature; the degree of this *expansibility*, as of its opposite effect, depending on the degree of the temperature. And lastly, in connexion with certain points of temperature, all the metals are capable of existing either in a solid or in a liquid state: and their property of passing from a solid to a liquid state, in consequence of the agency of heat, is called their *fusibility.*

Into the detail of the different degrees in which these properties are possessed by different metals, it belongs to the chemist to enter. What we have at present to consider is, the advantage accruing to society from these properties themselves, and from their existence in that particular degree in which they actually do exist in the different metals: to show, for instance, that those metals which possess malleability in a greater ratio than ductility, or ductility in a greater ratio than malleability, are of infinitely greater value than if the converse were true: and so with respect to the property of fusibility. Thus gold, being comparatively scarce, and principally valuable on account of its colour, its resplendency, and its remarkable power of resisting the action of the air, and of various agents which readily tarnish or rust the more common metals, (all which properties reside on the mere surface,) a given quantity of such a metal is consequently more valuable in proportion to the degree of its malleability; because it may be extended over a greater surface: and no metal possesses this property in so high a degree as gold; so that, as far as the eye is the judge, the most ordinary substance may be made to represent the most costly, at a comparatively trifling expense: while in the degree of its ductility, which in gold would be, for general purposes, of little moment, it is inferior to most of the metals.*

Iron, again, is malleable to a degree which renders it most valuable as a material for fabricating all kinds of instruments for mechanical, domestic, or philosophical purposes; and it is capable of being hardened by well known processes sufficiently for the numerous and important works of the carpenter and mason, and the equally important purposes of war, agriculture, and the arts. A greater degree of malleability, in a metal employed for such purposes as those for which iron is usually employed, especially as this metal is very easily corroded by rust, would clearly have added nothing to its practical value: while its degree of ductility, which exceeds that of every other metal, combined with its capability of being hardened in various degrees, occasionally confers a value on it greatly superior to that of gold.

From the difference in the degree of fusibility of different metals, aided by the disposition which they have to unite so as to form an alloy, arises the possibility of covering one metal in a solid state with a superficial coating of another metal in a state of fusion. I am not aware that this method is employed, at least to any extent, in any other instances, than in the application of tin to the surface of copper or of iron: but, were there a hundred similar instances, they would not lessen the value of this, as affording an illustration of that principle which has been borne in mind throughout this treatise. Consider only the respective degree of abundance of each of the three metals just mentioned, and the difference in some of their qualities with respect to external agents, and we shall have ample reason for being assured that, on this and on every other occasion, we may say of the Creator of material things—"In wisdom hast Thou made them all." And not only is it true that

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* It should be kept in mind that this observation is applied to unalloyed or pure gold; for, when alloyed, this metal is capable of being drawn out into a comparatively fine wire. Dr. Wollaston indeed suggested a method of drawing out even pure gold into an exceedingly fine wire, by enclosing it in a mass of a highly ductile metal, drawing out the mixed metal into fine wire, and disengaging the gold from the metal in which it was enclosed, by any acid which would dissolve the latter without affecting the gold itself.

> "The world by difference is in order found;"

but the difference is so adjusted in every instance, that, if it were varied, the value of the substances in which the difference is observable would be destroyed. Thus, of the three metals now under consideration, iron and copper, from the degree of their malleability, are easily formed into those various vessels which are of daily use for culinary and other purposes; while tin possesses the property of malleability in comparatively a slight degree: and, correspondently with the extent of their use, iron and copper are found in great abundance and in almost every part of the world; while tin is of very rare occurrence. Again, the two former metals are easily rusted; and, from the poisonous quality of the rust of copper, fatal effects on human health and life would be frequently occurring, used so extensively as that metal is for the construction of vessels in which our food is prepared, were it not defended by that superficial coating of tin, which is commonly applied to the inner surface of such vessels; tin being neither easily rusted, nor capable of communicating any poisonous quality to substances brought into contact with it. Let us then suppose that the respective degree of malleability, or of fusibility, were reversed in these metals; and observe the inconvenience that would ensue. Let the tin have that degree of malleability, for instance, which would render it capable of supplying the place of the iron, or the copper, in the construction of various economical vessels and instruments; yet, from the small quantity in which it occurs in the world, the supply of it would soon be either exhausted, or its price would be so enhanced that it could not be purchased except by the rich. And, even if the supply were inexhaustible, yet, from the softness of the metal, the vessels made of it would be comparatively of little use; and from the low temperature at which it melts, it could not be readily used for the generality of those purposes to which copper and iron are commonly applied. On the other hand, let the copper or the iron be as fusible as tin; and let the tin be as refractory under the action of heat as iron and copper are: in that case, how could the tin be applied with any degree of economy to the surface of either of the other two; while they themselves would be unfit, from their easy fusibility, to withstand that degree of heat to which they are necessarily exposed in many of the economical uses to which they are applied?

There remains to be considered one property of metals with respect to their fusibility, which is of the highest practical importance; for on this property depends the possibility of uniting together portions of the same, or of different metals, without fusion of the metals themselves. If two metals be melted into one uniform mass, the compound is called an *alloy;* and in the greater number of instances, if not in all, the alloy is more readily fusible than either of the component metals: and hence it easily becomes a bond of union between the two metals, or different portions of either of them. Such an alloy, when so employed, is called a *solder.* In considering the present subject, we cannot overlook a remarkable analogy between metallic substances and building stones, with reference to one mode in which they may respectively be united to each other, so as to form one solid mass; mortar being to stones what solder is to metals. Thus, in uniting two metallic surfaces by means of solder, it is requisite that the latter should be in a fluid state, or melted; and, in uniting the surfaces of two bricks or stones by means of mortar, the latter must be, if not in absolutely a fluid, yet in a soft and yielding state: and the final hardening of each is the efficient cause of permanent union. The period indeed requisite for the due consolidation of the uniting medium is very different; the solder becoming fixed in a few seconds, the mortar requiring some hours, perhaps days, for its consolidation: but, in the end proposed, there is no essential difference; for the mortar, if originally tempered well, and well applied, as firmly unites the stones, as solder the metals: so that mortar might be called a slowly acting solder; and solder, an extemporaneous or quickly acting mortar.

It would appear a paradox, if not an absurdity, to affirm abruptly that a liability to rapid decay is among the most important properties of any substance in general use: and yet this may be truly affirmed of iron. For though, in one sense, its liability to rust diminishes the value of this useful metal, because it is consequently almost impossible to preserve it very long in an entire state; yet, indirectly, this property, though detrimental to individuals, is beneficial to the community: for, in the first place, the presence of iron ore is so general, and its quantity so abundant, that there is no probability of any failure in its supply: and, in the next place, numerous branches of trade are kept in continued employ, both in working the ore, and in meeting the constantly renewed demand for implements made of iron, owing to the rapid corrosion of this metal.

Among the metals there is one, the history of which ought not to be overlooked on the present occasion, from the very circumstance that its value in a great measure depends on the absence of most of those properties which render all other metals valuable. Quicksilver is the metal in question: and what an anomaly does it not present in the general history of metals; existing, under all common variations of temperature, in a fluid state, while all other metals, with which we are familiar, are, under the same variations, solid; nor indeed are they capable of becoming fluid, but by an elevation of temperature to which they are hardly liable to be exposed, unless designedly: lastly, in consequence of its fluidity, destitute of malleability and ductility; which are among the most valuable properties of the metals taken collectively? This state of fluidity, however, is the very point on which the value of this metal in a great measure turns: for hence it is successfully employed for many purposes, to which, were it solid, it would be inapplicable. How valuable is its use in the construction of the common thermometer and barometer; the value, in the case of the former instrument, depending entirely on its fluidity, and on the physical characters of the fluid itself—the equable ratio, for instance, of its contraction and expansion under widely varying degrees of temperature; and its property of remaining fluid through a greater range of temperature than any other known substance.* And, in the case of the barometer, what fluid is there which could supply the place of quicksilver, with any degree of convenience? since, from the great specific gravity of this metal, a column of the perpendicular height of about thirty inches, sufficiently answers the intended purpose; which column in the case of almost every other fluid, would amount to as many feet. And as, in such a case, the column must necessarily be contained in a glass tube, in order to make the alterations in its height visible, how would it be possible to render such an instrument portable? and yet, if not portable, it would often be of no use when most wanted.

In those numerous philosophical experiments in which it is requisite to insulate portions of various gaseous substances, for the purpose of examining their properties, how could the experimentalist proceed without the use of the metal now under consideration; which by its fluidity readily yields its place to the various kinds of gas which are to be transferred to vessels previously filled with the quicksilver; and, having no chemical affinity for the greater number of gaseous substances, is calculated to retain them in an insulated and unaltered state for an indefinite length of time? nor let us forget to observe, how the properties of the metal, which is necessarily in contact with the gaseous substances in question, conspire with the properties of the glass vessels containing these gaseous substances, to facilitate the observations of the philosopher: for, if the glass were not both a transparent body, and equally devoid as the quicksilver of any chemical affinity for the gas contained in it, the metal itself would be of little use for the purpose intended; since we are not acquainted with any other substance that could supply the place of glass—with the exception perhaps of rock crystal; which however could only be procured in small quantity any where, and could not be worked into a convenient form but at a most enormous expense.

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* Quicksilver does not become solid till exposed to a temperature of about seventy degrees below the freezing point in the scale of Fahrenheit; nor does it pass readily into a state of vapour till exposed to a temperature equal to nearly three hundred and seventy degrees above the boiling point of water, on the same scale.

Section VII.

Common Salt, &c.

It does not appear that the mineral kingdom contains a single species capable of being employed as food: but there is one mineral species, which indirectly contributes to the nourishment of many other animals as well as man; and that is common salt: the flavour of which, to a certain extent, is not only grateful to the palate, but, practically speaking, mankind could not exist, or at least never have existed, without the constant use of it. Thus, though employed in very small quantities at a time by any individual, and almost exclusively for the purpose either of preserving or of rendering his food more palatable, this substance may fairly be classed among the principal necessaries of life: and, correspondently with this statement, we find that nature has supplied it in abundance, indeed in profusion often, in various parts of the globe: for, to say nothing of those apparently inexhaustible masses which occur among the solid strata of the earth, and which have been constantly quarried through successive ages from the earliest records of history, the ocean itself is a never-failing source of this valuable substance. In other instances salt springs afford the means of a ready supply: and, throughout a considerable part of the sandy districts of Africa and Asia, the soil itself abounds with it.* The abundant supply of common salt coincides with its extensive utility. It is every where indispensable to the comforts of man; and it is every where found, or easily obtained by him. And, though not to the same extent, the same observation holds with reference to many other natural saline compounds. Thus carbonate of potash, and natron or carbonate of soda, alum, borax, sal ammoniac, and sulphate of iron, or green vitriol, which are most extensively useful salts in many processes of the arts, are either found abundantly in various parts of the world, or may be obtained by very easy means: while a thousand other saline compounds, which are rarely of any practical importance, are scarcely known to exist in a native state. And it is probable that that useful metal, copper, in consequence of its frequent occurrence in a native state, was employed long before the mode of reducing iron from its ores had been discovered; as Werner (and Hesiod, and Lucretius, ages before him*) conjectured.

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* It does not belong to our present purpose to describe the common processes by which the salt is obtained either from the sea, or from any other liquid that may hold it in solution: but the following account of a particular process, for this purpose, so well illustrates the ingenuity of the human mind in taking advantage of natural hints, if the expression may be permitted, that no excuse can be necessary for its introduction. In Guiana there is a very common species of palm, the flowers of which are enveloped by a sheath capable of holding many pints of water; and the density and general nature of the sheath is such, that the water contained in it may be heated over a fire without destroying its substance: and the Caraibs actually employ these sheaths, in evaporating the sea-water for the purpose of obtaining a quick supply of salt. (Diction. des Sciences Nat. tom. xxxvii. p. 283, 4.)

CHAPTER VIII.

ADAPTATION OF VEGETABLES TO THE PHYSICAL CONDITION OF MAN.

SECTION I.

General Observations on the Vegetable Kingdom.

THE vegetable kingdom has this distinction with reference to the subject of the present treatise, that its productions are amongst the first objects that forcibly attract the attention of young children; becoming to them the source of gratifications, which are among the purest of which our nature is capable; and of which even the indistinct recollection imparts often a fleeting pleasure to the most cheerless moments of after-life.

Who does not look back with feelings, which he would in vain attempt to describe, to the delightful rambles which his native fields and meadows afforded to his earliest years? Who does not remember, or at least fancy that he remembers, the eager activity with which he was used to strip nature's carpet of its embroidery, nor cease to cull the scattered blossoms till his infant hands were incapable of retaining the accumulated heap? Who, on even seeing the first violet of returning spring, much more on inhaling its sweetness; or in catching the breeze that has passed over the blossom of the bean or of the woodbine, does not again enjoy the very delights of his early childhood?

It may be said indeed that the pleasure of such recollections is for the most part of a moral and intellectual nature; and, so far, is foreign to our present object: but the pleasure of the original enjoyment appears to be principally of a physical character; and is no doubt intended to produce, at the moment, a highly beneficial, though merely physical effect: for while the eye of the child is attracted by the unexpected forms and colours of the plants and flowers presented to his view, and his mind is instigated to gratify the eager desire of possessing them, he necessarily subjects his limbs to that degree of exercise and fatigue, which contributes to the general health of his body. Nor let such pleasures be undervalued in their consequence: they give that moderate stimulus to the whole system, which even the early age of infancy requires; and, by shutting out the listlessness that would arise from inactivity, they become eventually the source of moral and intellectual improvement.

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* Χαλκῷ δ' ἐργάζοντο, μέλας δ' οὐκ ἔσκε σίδηρος.

ΕΡΓ ΚΑΙ ΗΜ. line 151.

Posterius Ferri vis est, Ærisque reperta.
Et prior Æris erat quam Ferri cognitus usus.

LUCRET. V. 1285.

With reference to the primary wants of mankind at large, the vegetable kingdom is of the highest importance. Let the earth cease to produce its accustomed fruits, and every form of animal life must be soon annihilated: for all animals either derive their nourishment directly from vegetable food, or feed on those animals which have themselves fed on vegetables. And, without the aid of the same productions, we should be deprived of various substances which are now employed for clothing, and fuel, and the construction of our habitations. But the adaptation of the vegetable kingdom to the arts and conveniences of life is visible in numerous other instances: and the principal difficulty, in illustrating this point, is the selection of appropriate examples, and the order of their arrangement.

Section II.

The Cocoa-nut Tree, including the formation of Coral Reefs.

For the purpose of introducing in a more particular manner the general subject of this chapter, and as an impressive example of the important ends which nature often accomplishes by the simplest means, I propose to consider the mode in which the cocoa-nut tree is spontaneously propagated in the coral islands of the Indian Archipelago and elsewhere: nor will it be an undue anticipation of a subsequent department of this treatise, if I previously give a brief description of the process by which those islands have themselves been brought into existence. The account of their origin indeed belongs more strictly to the history of the animal than of the vegetable world; but the two subjects are so naturally connected, that it would be injudicious to separate them.

It may be collected from the observations of the French navigator, M. Péron, (Ann. du Mus. tom. vi. p. 30, &c.) that almost all those countless islands of the Pacific Ocean, which are found to the south of the equator between New Holland and the western coast of America, are either entirely or in part made up of coral: and all the adjacent ocean abounds with coral reefs, which, constantly augmenting, are constantly changing the state of bays, and ports, and gulfs; so that new charts are continually required for the same coasts. From Barrow also it appears, (Barrow's Cochin China, p. 167,) that the formation of coral reefs or isles is very common in the tropical parts of the Eastern and Pacific Ocean. And Captain Flinders says that the quantity of coral reefs between New Holland and New Caledonia and New Guinea, is such, that this might be called the *Corallian Sea.* (Flinders's Voyage, vol. ii. p. 314).

Many more references might be made, to others as well as the above-mentioned voyagers, in order to show that the formation of coral islands is effected by nature on a very extensive scale: but, for the present purpose, the preceding references may be considered sufficient. Let us now therefore describe the general character and mode of formation of these islands.

Forster says* that the low islands of tropical seas are commonly "narrow, low ledges of coral rock, including in the middle a kind of lagoon; and having here and there little sandy spots, somewhat elevated above the level of high water, on which cocoa-nuts thrive:" correspondent with which description is the account given by Captain Cook, on the occasion of discovering one of these coral reefs; which was at first mistaken by him for land. "This proved to be," he says, "another of those low or half-drowned islands, or rather a large coral shoal, of about twenty leagues in circuit. A very small part of it was land, which consisted of little islets ranged along the north side, and connected by sand-banks and breakers. These islets were clothed with wood, among which the cocoa-nut trees were only distinguishable. We ranged the south side of this shoal at the distance of one or two miles from the coral bank, against which the sea broke in a dreadful surf. In the middle of the shoal was a large lake, or inland sea, in which was a canoe under sail." (Cook's Voyage, 4to. 1777. vol. i. p. 141, 142.)

Coral, considered as an individual substance, is a natural form of carbonate of lime, produced by an animal of the polype kind. The particles of carbonate of lime, however produced, are cemented together so firmly by a glutinous secretion of the same animal, as to acquire a degree of consistence, which not only forms a safe habitation for a race of animalcules, from their soft texture most obnoxious to external injuries; but which is calculated to resist the utmost action of the sea, and in many instances to protect the original surface of the earth itself from its assaults. Thus almost all the tropical islands, which Cook saw in the South Pacific Ocean, are guarded from the sea, to a greater or less extent, by a reef of coral rocks, extending out from the shore to the distance of six hundred feet and farther; and on this reef the force of the sea is spent before it reaches the land: and thus nature has effectually secured these islands from the encroachments of the sea, though many of them are mere points when compared with that vast ocean.*

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* Forster's Voyage round the World, p. 14, 15.

As the specific gravity of coral is greater than that of sea-water, the structure of a coral reef necessarily commences either from the natural bed of the ocean, or from the surface of some submarine rock; and, as may be collected from the nature of the soundings among coral reefs, the whole structure is very frequently disposed in the form of a crescent; sometimes even approaching to a circle. This crescent is, on the convex side, built up throughout in very nearly a perpendicular direction; so as to form a wall, which is exposed to that quarter from whence a stormy sea most frequently prevails. The interior of the structure seems gradually to shelve off; so that about the centre of the inclosed, or partially inclosed space, the sea is found of its natural depth. Correspondently with such an arrangement, it happens usually that the soundings gradually lessen from the centre of the area inclosed by a coral reef, towards the exterior ridge; and then suddenly sink to two hundred fathoms or more.

To the foregoing observations I shall subjoin the opinion of Captain Flinders on the process observed by nature in the formation of coral reefs. "It seems to me," he says, "that when the animalcules, which form the coral at the bottom of the ocean, cease to live, there structures adhere to each other by virtue either of the glutinous remains within, or of some property in salt water; and the interstices being gradually filled up with sand and broken pieces of coral washed by the sea, which also adhere, a mass of rock is at length formed. Future races of these animalcules erect their habitations upon the rising bank, and die in their turn; to increase, but principally to elevate, this monument of their wonderful labours. The care taken to work perpendicularly, in the early stages, would mark a surprising instinct in these diminutive creatures. Their wall of coral, for the most part in situations where the winds are constant, being arrived at the surface, affords a shelter; to leeward of which their infant colonies may be safely sent forth: and to this, their instinctive foresight, it seems to be owing, that the windward side of a reef, exposed to the open sea, is generally, if not always, the highest part; rising almost perpendicularly, sometimes from the depth of two hundred and perhaps many more fathoms. To be constantly covered with water seems necessary to the existence of the animalcules; for they do not work, except in holes upon the reef, beyond low water-mark: but the coral sand, and other broken remnants thrown up by the sea, adhere to the rock, and form a solid mass with it, as high as the common tides reach. That elevation surpassed, the future remnants, being rarely covered, lose their adhesive property; and, remaining in a loose state, form what is usually called a *key* upon the top of the reef. The new bank is not long in being visited by sea birds; salt plants take root upon it, and a soil begins to be formed; a cocoa-nut, or the drupe of a pandanus, is thrown on shore; land birds visit it, and deposite the seeds of shrubs and trees; every high tide, and still more every gale, adds something to the bank; the form of an island is gradually assumed; and, last of all, comes man to take possession."*

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* Cook's Voyage, 1777, 4to. vol. i. p. 212.

In the base of a coral island of the above description, Captain Flinders distinguished not only the sand, coral, and shells, formerly thrown up, in a more or less perfect state of cohesion; but also small pieces of wood, pumice-stone, and other extraneous bodies, which chance had mixed with the calcareous substances when the cohesion began, and which in some cases were still separable from the rock without much force.† Such sand-banks are found in different stages of progress; some being overflowed with every returning tide; some raised above high-water mark, but destitute of vegetation; some, lastly, habitable and abounding in trees.

Let us here pause for a moment to contemplate the wonderful effect produced by apparently the most inadequate means. And wonderful indeed is the effect, even if the process above described were now to cease for ever; but much more, if we look to its probable extension: for, reasoning on what has already been accomplished, and on what is at this moment rapidly advancing, it is evidently probable that a new habitable surface of land may be eventually produced, equal in extent to the whole of Europe, and produced by the agency of a tribe of animals, which occupy very nearly the lowest steps in the scale of animal creation, and which in every other respect are the most inefficient and helpless of creatures. For, fixed as they are, both individually and collectively, to a completely local habitation; or, rather, buried as it were in a strong mass of coral, and literally

"Each in his narrow cell for ever laid,"

their general appearance and mode of growth so little resemble the animal character, that, for a long time, many of the species were considered as of vegetable origin; and are, even now, very commonly called *zoophytes*, or animated plants.

Nor let us fail to observe, in the foregoing account, the physical fitness for each other of two very different departments of nature. The same geographical climate which gives birth to those animals, whose labours produce this previously unexpected habitable surface, gives birth also to those vegetables, which, at the same time that they are capable of growing on so loose and poor a soil, are capable besides of supplying its future inhabitants not only with nutritious food, both in a liquid and a solid form, but with materials for constructing their habitations, and for many other useful purposes. And in the mean time the fowls of the air, and the very winds and waves, are all employed in administering to the beneficent intentions of Providence. Of little use would be a new habitable surface, were it never to be tenanted by human beings; and in vain would man attempt to colonize that surface, were it barren of vegetable productions: but the seeds of various plants, as we have seen in the foregoing descriptions, are either brought by birds, or drifted by the wind and waves, to a soil calculated to support them.

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* Flinders Voyage, vol. ii. p. 115, 116.

† Ibid, p. 116.

Among the vegetable productions of coral islands, the cocoa-nut tree stands pre-eminent in value; containing in itself nearly all those important properties, which are found at large in that natural family of plants, the palms: and valuable indeed are those properties, if we may rely on the accounts which have been given of them by different authors; and of the truth of those accounts there is no sufficient reason to doubt. Johnston,* speaking of the abundance of the cocoa-nut tree in India, where he says it occurs to a greater extent than the olive in Spain, or the willow in Holland, affirms that there is no part of the tree which is not applied to some useful purpose. Not only the cabins of the poorer natives, but large houses, are constructed entirely with materials afforded by this tree; the trunk, when split, supplying rafters, &c.; and the leaves, when plaited, making roofs and walls, which are impervious to wind and rain. The statement of Johnston is confirmed by captain Seely, in his account of Ellora†, who says that "when he was stationed at Goa, in 1809, he lived, as many others did, in a cocoa-nut leaf house; and that although the period was in the very height of the monsoon, and the house was on the sea-coast, it was comfortable and warm. He believes that not a nail was used in the whole building: the rafters and supporters, &c. were fastened on with string made of the fibrous envelope of the cocoa-nut shell; the wood was the tree itself; the roof, walls, doors, and windows were the leaf." From the same anthority we learn that the fibres, enveloping the shell of the nut, may be woven into a cable by which ships of seventy-four guns have safely rode out heavy gales, when European cables have parted.

In the Wernerian Memoirs, vol. v. p. 107, &c., is a very interesting account of the cocoa tree; in which the author states that this tree will grow on the sand of the sea-shore, where scarcely anything else will vegetate: which corresponds with the account of an author above-mentioned, who, speaking of its growth, says, "radicem habet tenui spatio porrectam; et quæ quasi contra fidem terræ inhæret."* And these statements are quite in accordance with the observations of captain Flinders.

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* Johnstonus de Arboribus, p. 146, &c.

† London, 1824, 8vo. p. 284.

From other sources we learn that this tree bears fruit twice or thrice in the year;† that the half-ripe nut contains sometimes three or four pints of a clear aqueous fluid, fragrant, and pleasant to the taste; and that the nut itself, from its highly nutritious qualities, is used as an aliment in all inter-tropical countries.‡ In the volume of the Wernerian Memoirs above-mentioned, it is said that in 1813 the number of cocoa trees cultivated in Ceylon, along a line of coast of about 184 miles, was ten millions, and that that number was increased in following years; that this tree is fruitful from its eighth to its sixty-fourth year, and sometimes bears from eighty to one hundred nuts annually; that elephants are fed on cocoa nut leaves; and that the ashes of the tree contain so great a proportion of potash, that the native washermen of Ceylon use them instead of soap.§

In the Nouv. Dict. d'Hist. Nat. tom. vii. p. 297, &c. it is stated, that, as in other palms, if the extremity of the sheath from whence the flowers of the cocoa arise be cut off while young, a white sweet liquor distils from it, which is used extensively as a beverage in India under the name of *palm wine;* that this liquor, if concentrated by boiling, deposites a sugar; that if exposed to the air it acquires vinous properties at the end of twelve hours, and at the end of twenty-four hours becomes vinegar; that an oil may be obtained from the nut, which is not inferior to sweet almond oil, and which is used almost exclusively in India; and that the shell is formed into cups and various other small articles.

Almost all that has been said of the cocoa tree might be repeated of the date tree, making an allowance for the specific differences of the two: and with respect to the palms in general, Humboldt says it would not be easy to enumerate the various advantages derived from them. "They afford wine, vinegar, oil, farinaceous food, and sugar; timber also, and ropes, and mats, and paper; and," he adds, that, "no trees are so abundant in fruit, even without the aid of cultivation; and that the Franciscan monks, who live in the vicinity of palm plantations, near the banks of the Orinoco, observe that the native Indians give evidence of a fruitful palm year, by the corresponding improvement in their health and appearance."‖

I shall conclude this part of the subject with a translation from the Flora Atlantica of Desfontaines, for the introduction of which no apology, I trust, is necessary. In describing the natural scenery of groves of palm, the author concludes with the following beautiful passage: "These palm-groves, being impervious to the sun's rays, afford a hospitable shade, both to man and other animals, in a region which would otherwise be intolerable from the heat. And under this natural shelter, the orange, the lemon, the pomegranate, the olive, the almond, and the vine grow in wild luxuriance; producing, notwithstanding they are so shaded, the most delicious fruit. And here, while the eyes are fed with the endless variety of flowers which deck these sylvan scenes, the ears are at the same time ravished with the melodious notes of numerous birds, which are attracted to these groves by the shade, and the cool springs, and the food which they there find."*

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* Johnstonus de Arboribus, p. 145.

† Nouv. Dictionn. d'Hist. Nat. tom. vii. p. 297, 298. ‡ Ibid.

§ Wern. Mem. vol. v. p. 110—127.

‖ Humboldt, Distrib. Géogr. Plant. p. 216—240.

Section III.

Vegetables as a Source of Food.

It appears from various statements of authority, that the species of vegetables already known amount to about sixty thousand:† though there is reason to believe the actual number is above a hundred thousand:‡ and, from the general analogy of nature, we may fairly conclude that no species exists without its use in the economy of the earth. Of many indeed we witness the direct use, either for the various purposes of civilized society, or for the sustenance of animal life: but for the present let us confine our attention to the latter point in their history; and, although whatever is adapted to the sustenance of animal life in general, is indirectly adapted in a great measure to the actual condition of man, and would therefore justly come within the scope of this treatise; yet, that we may not extend the subject too far, let us consider those species only which constitute the direct food of man; subject indeed frequently to such culinary preparations as make our food not only more palatable, but also more nutritious.

Among the numerous species of vegetables which supply food to man, by far the greater proportion consists of those which may be considered upon the whole as mere luxuries; or at most, as affording an agreeable and sometimes useful variety. Of those species which afford that kind of nutritive matter which is contained in what has been emphatically called the staff of life, or bread, the number is very small; leguminous plants, and wheat, and rice, the fruit and pith and other parts of some of the palms and bananas, and such farinaceous roots as the potato, &c. comprising nearly the whole amount.

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* Palmeta radiis solis impervia, umbram in regione calidissima hospitalem incolis, viatoribus, æque ac animantibus ministrant. Eorum denso sub tegmine, absque ordine crescunt aurantia, limones, punicæ, oleæ, amygdali, vites, quæ cursu geniculato sæpe truncos palmarum scandunt. Hæ omnes fructus sauvissimos, licet obumbratæ, ferunt; ibique mira florum et fructuum varietate pascuntur oculi; simulque festivis avium cantilenis, quas umbra, aqua, victus alliciunt, recreantur aures."

Desfontaines, Flora Atlantica, tom. ii. Append. p. 439.

† Conversations on Vegetable Physiology, vol. ii. p. 108.

‡ Decandolle, Théorie Elém. de la Botanique, 8vo. 1819, p. 25.

It would be unnecessary to point out more particularly the importance of some of the foregoing species, to any one at all conversant with the general mode of life of Europeans as to food: and a slight acquaintance with the history of the world is sufficient to show us, that, what wheat and potato are to Europe, rice is to a considerable portion of Asia, Africa, and America; and the products of the date and cocoa, palms, &c. to the inter-tropical countries of the whole earth. But there are some natural analogies afforded by those species, with reference to the animal kingdom, which are well worthy of observation.

In the animal kingdom all those species which serve extensively for food, as oxen and sheep and swine among quadrupeds; the turkey, the common fowl, and the duck, &c. among birds; and the salmon, cod, and herring, &c. among fish, are either naturally of a gregarious nature, or are easily kept together, by human means, in large bodies; and therefore are much better adapted to the purpose of supplying food to man, than if they were either solitary, or scattered into small groups. And so it is with respect to the vegetable species above described: they are capable of being cultivated, gregariously, as it were, with comparatively little labour and attention. Thus in our own, and other European countries, the daily labourer, after his hours of hired work for others, can cultivate his own private field of wheat or of potatoes, with very little additional expense of time or trouble. And as to the cultivation of the tropical fruits, scarcely any labour is required for that purpose: so that to the less hardy natives of those climates the assertion of the poet is strictly applicable.

> "Fundit humi facilem victum justissima tellus,"

A further analogy is observable in the degree of fertility of the respective vegetables and animals. Among the animals which are destined for the food of man, the species are upon the whole prolific in proportion as they are either small in size, or inferior as to the nutritive quality of their flesh. The cow, which is a large animal, produces one usually at a birth; the sheep, very commonly two; swine, several. Poultry, which are comparatively small, are capable of rearing a numerous brood; and fish, which are of a less nutritious nature, and generally smaller than quadrupeds, are still more prolific. And, similarly, in the vegetable species which are destined for the food of man, the numerical quantity of the product in a given area is greater or less, in proportion to the individual size of the fruit produced. Dates, which are smaller than cocoa-nuts, are produced in greater number than the latter; and in a square yard of soil, a much greater number of grains of rice or wheat is produced than of roots of the potato.

Lastly, another analogy may be observed with reference to the palate. The taste of the flesh of these species, which constitute to man the staple as it were of animal food, is acceptable to most palates. And it is neither so rich as soon to cloy the appetite on the one hand, or invite it to luxurious indulgence on the other; nor so devoid of flavour, as to deter us from taking a proper quantity. And is it not the same with respect to those vegetable species, which are among the most ordinary and most necessary articles of our food? If corn, and the potato, and the cocoa-nut, had the pungency of euphorbium, the nauseating quality of ipecacuan, the heat of pepper, or the luciousness of sugar, on the one hand, or the insipidity of powdered chalk on the other; what an undertaking would it be to satisfy the craving of hunger with any one of those vegetables!*

It will be vain to urge, in opposition to the foregoing position, that custom in particular instances renders many things tolerable, and even pleasing to the taste, which at first were disgusting; for it would be found that in such instances custom has arisen from necessity, which often brings us acquainted with strange companions; or from a depraved taste. None have ever consented voluntarily to feed on the flesh of horses, or of ravens; and *caviare* will always be *caviare* to the multitude.

Next in importance to those vegetable species which either afford the material of bread, or an equivalent for it, may be classed those which contribute partly to the *nourishment* of man, and partly to his *health* and solace. The human system certainly may be, and too often from necessity absolutely is, supported solely on the nutriment afforded by the former species: but if we view the actual state of society, we find that many vegetable species and products may now properly be classed among the necessaries of life, which for many ages remained either undiscovered, or were only locally known, or sparingly employed; of which it will be quite sufficient to mention tea,† and sugar, and the potato. The sugar cane has for such a length of time usurped the prerogative of supplying the world with sugar, that other sources have been little considered: but even in cold climates there are plants capable of affording it in considerable quantities. There is, for instance, a species of maple cultivated in North America for the sake of the sugar obtained from its sap, which is capable of returning a very great profit to its cultivator; of which the following document, copied from a note by Dr. Hunter in his edition of Evelyn's Sylva, is a sufficient proof; there being no reason to suspect any fraud.‡ It is added in the same note, that a single family, consisting of a man and his two sons, on the maple-sugar lands between the Delaware and Susquehanna, made 1800lbs of maple sugar in one season. The whole note, consisting of eight closely printed quarto pages, which appears to have been furnished by Dr. Rush of Pennsylvania University, is well worth the perusal.*

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* On many occasions, however, pungent, or aromatic substances, as garlic, mustard, and spices, added to food comparatively of little flavour, as rice, &c. make it more palatable, and more easily digestible.

† During five years, beginning with 1826, about one hundred and fifty million pounds of tea were sold at the East India House, the average annual consumption being, according to the preceding statement, thirty million pounds.

‡ "Received, Cooper's Town, April 30, 1790, of W. Cooper, sixteen pounds, for 640 pounds of (maple) sugar, made with my own hands, without any assistance, in

If we consider the subordinate wants of the animal economy, we must in reason allow that those succulent fruits and vegetables, which are abundantly produced in almost all parts of the world, are destined by Providence for an important end with reference to the food of man. The very form and arrangement of our teeth, and the structure of our stomach, show, that our system is naturally adapted to a mixed food: and although those of our teeth, which resemble the corresponding teeth of carnivorous animals, are so little developed as to make it in that respect doubtful whether nature intended us to live on flesh; yet our stomach, and the rest of our apparatus of digestion, aided moreover by culinary preparation, certainly approximate us fully as much to the carnivorous as to the herbivorous classes. It is obvious, moreover, that we have an ample array of teeth for cutting and grinding vegetable matter. This then being the case, we might antecedently expect that our natural taste would lead us to enjoy the flavour of vegetable, as well as animal food; and that nature would supply us with a variety of the one as well as of the other; for variety itself is salutary.

And on this as on every occasion, we have an opportunity of seeing how Providence not only meets all the wants of mankind, but meets them in such a way as their local situation requires. Thus wheat, which contains a more strengthening principle of nutrition than the product of the palms and arrow-root, and is therefore better calculated to support the hardier efforts of the inhabitants of temperate or cold climates, will not grow readily in inter-tropical climates;† and, reciprocally, the palms and cognate plants of inter-tropical regions cease to be productive, if cultivated much beyond the tropics.‡ And the orange, the lemon, the water-melon, the grape, and the fig, which are easily cultivated in warm climates,§

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less than four weeks; besides attending to the other business of my farm, as providing fire-wood, taking care of the cattle, &c.

"Witness R. Smith." "John Nicholls."

Silva, 3d ed. by A. Hunter, York, 1801. vol. i. p. 190.

* The tree commonly called the sycamore, which is really a species of maple, yields a sweet sap, which has occasionally been used to supply the place of malt in brewing. Ib. p. 200.

† Desfontaines, Flora Atlantica, tom. ii. Appendix, p. 438.

‡ Wern. Mem. vol. v. p. 112.

§ An interesting fact is related in the "Conversations on Vegetable Physiology" respecting an artificial mode of ripening the fig. In hot climates the fig-tree produces two crops of fruit: and the peasants in the isles of the Archipelago, where the fig-tree abounds, bring branches of wild fig-trees in the spring, which they spread over those that are cultivated. These wild branches serve as a vehicle to a prodigious number of small insects of the genus called *cynips*, which perforate the by the abundance of their juice, are enabled both to allay the sensation of present heat and thirst, and to repair the loss of that natural moisture of the body, which is continually passing from it in the form of either sensible or insensible perspiration. Even in the temperate climate of our own island, how many days are there, during the summer, in which such fruits are most refreshing: and to gratify the desire of that refreshment we import such species as are capable of bearing a long voyage; among which the orange is a very principal article of import: nor would it be easy to calculate the myriads of that fruit which are annually consumed in this country. But the cognate fruit, the lemon, at the same time that, on account of the grateful and aromatic flavour of its juice, it is occasionally as eagerly sought as the orange, serves a still higher purpose: for the acid contained in it has been successfully employed, as an antidote and a remedy for one of the most dreadful diseases to which mariners are subject. Sea-scurvy in fact has all but disappeared since the general adoption of this remedy*.

Section IV.

Vegetables as applicable to Medicine.

If vegetables are valuable on account of their power of affording sustenance and keeping the body in a state of health, they are also valuable on account of their power of restoring health where it has been impaired: for, however sceptical some minds may be as to the powers of medicine in general, and however ignorant even the most sagacious and experienced medicinal practitioners may be as to the precise mode in which any medical substance acts on the human constitution; yet this at least is certain, that, in by far the greater number of instances, certain symptoms which indicate a disturbed state of the system are mitigated, and finally subdued, in consequence of the exhibition, to use a technical term, of certain reputed remedies. And it is open to the observation of almost every one, that the vegetable kingdom is the most fertile source, not only of the commonest and least efficient, but of some of the most powerful medicines with which we are acquainted. Nor can we doubt, when we see similar effects resulting from the use of the same medicines in

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figs in order to make a nest for their eggs; and the wound they inflict accelerates the ripening of the fruit nearly three weeks; thus leaving time for the second crop to come to maturity in due season." (Vol. ii. p. 41, 42.)

* It is probable that fresh vegetables of any kind are sufficient to prevent or to remove scurvy: for it is stated in Sauer's account of Billings's expedition, that that disease disappeared, even in so high a northern latitude as the Aleutan islands, as soon as the new vegetation sprang up in April (p. 276); and many other evidences of the same fact might be easily adduced.

individuals of very different constitutions, that the peculiar qualities of those substances, with respect to the effects they produce in the human system, were imparted to them by nature with a view to their application to those ends.

It may have happened to any one in the course of the last few years, during which intermittent fever or ague has prevailed very generally in this country, to witness the severe nature of some symptoms of that disease; paroxysms of dreadful rigour or shivering; nausea; intense headache, with delirium; paralytic affections of the limbs; and burning heat of the whole body, terminating in profuse perspiration: and whoever has witnessed such symptoms, recurring in the same individual at stated intervals, has probably seen their return at once arrested by a few doses of Peruvian bark, in the state of powder; the effect of which remedy, in subduing a violent disease, compared with the small quantity of it employed for that purpose, has been not inelegantly though playfully illustrated by that passage of the Georgics, in which the husbandman is taught to allay the occasional contests and agitations of the bees, by scattering a handful of dust among them.

> "Hi motus——atque hæc certamina tanta
> "Pulveris exigui jactu compressa quiescent."

And, if the vegetable kingdom had failed to afford any other medicinal substance than this, mankind would have still had ample cause for thankfulness.

But, even in the instances of those remedies from which nothing beyond a present or temporary alleviation is expected, the benefit usually accruing cannot easily be estimated at too high a rate: and one remedy there is, of this nature, for which mankind is indebted to the vegetable kingdom exclusively. How often has not opium lulled the most excruciating agonies of pain? how often has it not restored the balm of sleep to the almost exhausted body; or quieted those nervous agitations of the whole system, the terrors of which none perhaps can duly appreciate but those who have experienced them? There are however diseased or unnatural states of the body, in which no direct remedy can be applied, and all soothing means would not only be ineffectual, but fatal: in such states those substances, which are directly opposed in quality to opium, and irritate instead of soothing the surfaces to which they are applied, are valuable precisely on that account: they rouse the system, for instance, from a state of lethargy, which otherwise would probably terminate in death; or they stimulate the stomach to reject any substance of a poisonous nature, which may have been either intentionally or accidentally introduced into it, and they thus contribute to the preservation of life. Remedies of this character, though not exclusively belonging to the vegetable kingdom, are frequently afforded by it.

But, in enumerating the medicinal auxiliaries which mankind derive from the vegetable kingdom, let me not omit the restorative virtue of that gift of Heaven, which, though by its abuse it may intoxicate the mental faculties and undermine the general health of the body, is calculated most assuredly, when rightly used, not only to revive the drooping energies, but to rekindle the almost expiring spark of life. Survey the wretched subject of what is called *typhus*, while oppressed by those symptoms which justify the use of this restorative; when the glazed eye and squalid skin, the feeble circulation and muttering delirium, announce the near approach of death, unless the proper medicine be interposed; and then watch the beneficial effect of this divine remedy. They who have witnessed the progress of typhus fever in some of its forms, and in individuals who have lived in crowded and ill-ventilated habitations, will acknowledge that in very many instances wine alone has, humanly speaking, rescued the patient from the grave.

Nor will it be irrelevant to the general subject of this treatise to consider the natural origin of wine: by which I mean, not the mode or time of its discovery; either of which it would be as useless as vain to attempt to investigate, since this liquid was in common use at a period long antecedent to history: but by its natural origin I mean the circumstances under which it is usually produced. There is a law in nature, by which organised bodies, vegetables as well as animals, are disposed to undergo spontaneous decomposition very soon after they have ceased to live; the ultimate result of which is, a resolution into their elementary principles; in other words, they putrefy and perish. But even in this state, in which they are deprived of all their former properties, they administer to the good of man; and, under the name of manure, are known as the principal means of fertilizing the ground; from whence all his food is ultimately obtained. The circumstances, however, which accompany this change in vegetables, differ very much from those which attend the corresponding change in animals; and may be well illustrated by a reference to the process of making any common wine.

If a sufficient quantity of the juice of ripe grapes, or of any other saccharine fluid, be exposed to a moderately warm temperature, an internal movement of its particles soon begins to take place; which is technically called *fermentation:* and during the period when this is going on, the sugar of the liquor is, in part, converted into wine. If the fermentation be now arrested by the proper means, the whole mass of the liquid may be preserved in nearly the same state for a longer or shorter period, in proportion to the quantity of wine contained in it: but if, after the vinous fermentation, as it is called, has been completed, the temperature be to a certain degree increased, the wine is converted into vinegar by a continuance of the process of fermentation: and, ultimately, the acid taste and odour of the vinegar are lost; and the whole mass of the liquor becomes first vapid, and then putrid.

That such a process of putrefaction should take place in organised bodies after their death, might in reasoning be antecedently expected; for the purpose of administering to the growth of their successive generations in the case of vegetables;* and to prevent the indefinite accumulation of so much dead and useless matter in the case of animals: but we could not have anticipated, that, while animal matter at once passes into a state of putrefaction, vegetable matter should previously pass through two intermediate states; accompanied with products which in their nature differ both from each other, and from the source from which they were derived: both, however, as we might very reasonably expect from the known wisdom and beneficence of the Creator, of the highest importance to mankind.

From wine, to say nothing of the advantages resulting from its proper use in its common state, is derived that useful fluid called *alcohol*, or spirit of wine: among the most valuable properties of which, may be ranked its power of dissolving resin, and other vegetable principles; and of preserving organized matter from the putrefactive process. In consequence of the former power, it is employed to extract from various vegetables some of those parts in which their medicinal virtues reside; and to preserve them in a convenient form for immediate use, at any moment, under the technical name of *tinctures*. And with respect to its importance as a preservative of animal and vegetable matter, but particularly of the former, I need only point out any one of those collections of anatomical preparations contained in the museums of every medical school in Europe. But if any single instance of its application to this purpose be demanded, who can hesitate to name that astonishing proof of the genius and industry of the great English physiologist, John Hunter, the Collection preserved in the Royal College of Surgeons? on the pedestal of whose bust, placed within the walls of the museum of that college, might well be inscribed, as I believe has been often suggested, those appropriate words,

> "Cujus monumentum si quæras, circumspice."

SECTION V.

Vegetables as applicable to the Arts, &c.

In considering the application of natural substances to the various purposes of life, it is often interesting to compare the simplicity of the orginal contrivance with the complicated manipulations of the process by which, at the present day, a material, destined for a specific use, is brought into a fit state for that use. Let fine writing-paper be taken as an instance; and let us compare the history of a piece of such paper with that of the simple material on which many Oriental manuscripts are written—the mere leaf of a tree, probably some species of palm,—which after having been cut into the requisite size and form, seems to have undergone no other preparation than simple pressure; partly with the view of forcing out its natural moisture, and partly of smoothing its surface. How different the history of the paper that is daily fabricated in any of the large manufactories of this country; and how little would its origin and numerous changes of state be conjectured from its present appearance! Heaps of linen rags of every colour, when indeed that colour can be distinguished through the dirt which adheres to them, are brought from almost every quarter of Europe; each rag having probably been part of some article of dress, which as it grew viler by use, passed from a more to a less respectable possessor; till it at length became the tattered and threadbare covering of the poorest mendicant.

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* "Haud igitur penitus pereunt quæcunque videntur:
Quando aliud ex alio reficit Natura, nec ullam
Rem gigni patitur, nisi morte adjutam aliena."
LUCRET. I. 263—5.

From such a material is the finest paper made: and, in the commencement of the process, each individual rag undergoes an examination with respect to its size, and is cut into two or more pieces according to that size. Separate heaps are then mechanically shaken together, and sifted, in order to clear them from adhering dust: they are subsequently washed, mechanically divided into small shreds, bleached, then thrown into vats of water, and there reduced to a fine pulp by the application of powerful machinery. This pulp, by very delicate yet simple means, is kept in a state of close and equable diffusion over an even surface, and is made to pass between successive pairs of smooth metallic cylinders; all of which, by pressing out the moisture of the pulp, bring its particles more closely together, and thus tend to give it the requisite degree of firmness and cohesion; the last pair being heated sufficiently to dry the paper during its passage between them.

Such are the numerous and elaborate processes, by which a heap of sordid rags is converted into the beautiful material of which we have been speaking. And if, to the accumulated processes to which each rag is submitted during its fabrication into paper, be added its previous history, as the cultivation and subsequent dressing of the flax of which it was made, the formation of the fibre of the flax into thread, the weaving of the thread into linen, and, in the majority of instances, the dying of the linen; if all these points be collectively considered, what food for a reflecting mind does not the minutest particle of the resulting paper afford!

Many plants are capable of yielding a colouring matter, which by chemical means may be readily made to combine with various substances, as linen, woollen, silk, and leather. This property, which sometimes resides in the stem and branches, sometimes in the leaves and flowers, may be classed among those properties of plants, which, if we consider the actual state of society in all the civilized parts of the world, are productive of the greatest advantage to mankind. Hence, for instance, has arisen an art, the art of dying, which not only opens a wide field of employment to a numerous class of workmen, in every large city; but gives a degree of activity to general commerce, which cannot but surprise the mind of any one previously ignorant of the circumstance. Thus the quantity of indigo, accumulated in the extensive repositories of the East-India Company, is frequently so great as to make the occasional observer wonder that it should ever find a market: and the following statement will show how important this single substance is as an article of commerce. During the last five years, the quantity of indigo imported into London amounts to at least one hundred and twenty thousand chests; the average weight of the contents of each chest equalling 270 lbs., and the average price of each pound being five shillings. The estimated value therefore of the indigo contained in the 120,000 chests would be rather more than eight millions sterling.

If I am correct in supposing that *blue*, *red*, and *yellow*, are the colours most abundantly supplied by vegetables, it cannot fail to strike a mind of the least reflection, that these are precisely the elementary colours which a dier would have antecedently selected, in order to be enabled to practise his art to the greatest advantage; since from these three, all other colours or tints may be obtained. And with respect to black, which must practically be considered as a distinct colour, though not admitted as such theoretically, it is worthy of observation, that, although scarcely any vegetable substance yields it directly; yet, by the intervention of almost any form of iron, and this metal is in some shape or other present everywhere, it may readily be produced from a very numerous class of vegetable substances. In almost every instance where a vegetable substance has an austere and bitter taste, it will with iron give a die of a black colour. Thus the bark of the oak, and of many other trees, and that vegetable excrescence called the *gall-nut*, produce an ink by the addition of any saline form of iron.

From the earliest and least civilized times, and through every intermediate stage of society to the present period of refinement, the productions of the vegetable world have been in constant request for the most common purposes of life. The simplest dwellings not only of the uninstructed savage, but of the peasantry of many parts of modern Europe, are constructed almost entirely of wood; the simplest implements of husbandry, the plough, the spade, and the hoe, could hardly be employed without the aid of a wooden frame-work or handle: and the same observation holds good with reference to the tools of the most necessary arts of life. How great would be the inconvenience, and how increased would be the labour of the carpenter, or the smith, or the mason, if, instead of wood, the handles of his implements were of iron! Nor are substances of vegetable origin of less importance, or less generally employed, in many of the higher arts of life. Examine the structure of a man of war—its hulk, of oak; its masts, of fir; its sails and ropes, of flax; its caulking, of tow and of tar. All is of vegetable origin from the top-mast head to the keel itself. With the exception indeed of the iron which is occasionally used in the construction, no metallic substance is necessarily employed; for the copper sheathing, though highly useful, is certainly not necessary.

It would require volumes to describe all the economical uses to which vegetables are applied. How many important trades arise from this source. How many families, now existing in opulence, originally derived their surnames from their occupation, and that occupation connected with vegetable materials; for instance, Cooper, Carpenter, Dier, Tanner, Turner, Wheeler, Weaver, Barker, Hayward, Gardener, Cartwright, Miller, Fletcher, Bowyer!

And then, to answer the various purposes to which they are to be applied, how widely do the qualities of different vegetable productions differ from each other! How well the rigid fibre and compact texture of the oak enable the bulky vessel to resist the buffeting of the waves! The ash, the beech, the fir, the yew, each has those appropriate qualities which make it individually preferable to the rest. The flexibility of the hemp and flax renders them capable of being woven and formed into sails and cordage; and, exposed as the sails and rigging are to the vicissitudes of the weather, how well are they protected by being covered over with tar, itself of vegetable origin!

Some woods very readily split with that regularity of surface which we observe in common laths; and of the utility of that kind of material in almost every kind of building no one can well be ignorant. Other woods, as the willow, very readily bend, with a considerable degree of elasticity, in every direction; and hence are of value in the fabrication of what is known under the general name of wicker-work.*

In this department, again, though not to the same extent as in the case of some of the metals, is seen the effect of human labour in advancing the value of the original material. Compare, for instance, the mercantile value of a piece of fine lace, with the original value of the material of which it is made.

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* The art of making wicker-work is often successfully cultivated at a very early period of civilization. Thus, in the neighbourhood of California, some of Captain Beechey's officers were supplied with "water brought to them in baskets, which the Indians weave so close, that, when wet, they become excellent substitutes for bowls." (Beechey's Voyage, p. 385.) And we know that, not long after the conquest of Britain by Cæsar, the ornamental wicker-work of the natives was highly prized at Rome.

There are many plants, which, though they neither produce fruit of any value nor are capable of being applied to any of the common purposes of the arts, are yet of the highest value as a natural defence to cultivated lands against the incursions of cattle; and sometimes even against the attacks of disciplined troops.

The quickset of our common hedges is an instance of the former application; and of its utility in this country no one can doubt, unless he happen to live exclusively in those districts, as in certain parts of the Cotswold and similar ranges of hills, where stone supplies a more ready material for a fence. Of the extent of its application, it would not be easy to make a correct estimate: but, when we consider how many public roads, and how many private enclosures are bounded by a fence of quickset, it becomes probable that the linear extent of hedges of this kind is, in England alone, equal to many times the circumference of the whole earth. In describing one of the most important fortresses in the Deccan, Captain Seely, in his account of the temples of Ellora, states that the town, which stands about 1020 yards from the fort, is surrounded by a hedge of prickly pear, nearly eighteen feet high, and thick in proportion. This natural defence round towns and villages on the western side of India is very common; and it offers to a predatory body of horse or foot a formidable barrier: for the sharp and long thorns, which project from the stem and leaf, not only act as an immediate defence; but, if broken off, they exude a liquid which often produces severe inflammation.*

In a part of Normandy, lying between Caen and Falaise, is a district called "Le Bocage" (*petit bois*), which "derives its name from the high and bushy hedges with which it abounds; and which are designed to afford shelter from the stormy winds of the Atlantic. There are but few trees in those parts; but the hedges, being from eight to ten feet in height, are sufficient to protect the crops from the boisterous sea-breezes: and they thence bear the name of *brise-vent.*"†

The last point in the history of vegetables which I propose to consider is their application as fuel; and many nations entirely derive their supply of fuel, for culinary and other domestic purposes, from the vegetable kingdom alone: and even where such a supply is in a great measure needless, on account of the abundance of coal, yet, for many purposes, various forms of wood, either in a recent or in a charred state, are preferred, on account of the injurious effects arising from the sulphur with which coal is usually contaminated; in the heating of bakers' ovens, for instance, in the drying of malt, and in numerous processes of the arts. Around the shores of the Arctic Ocean, where scarcely any traces of native vegetation are observable, the inhabitants are amply supplied by drift-wood (Sauer's account of Billings's Expedition, p. 104—259). And Captain Beechey says, that drift-wood is to the Esquimaux what forests are to us; being in such abundance and variety, that the inhabitants have the choice of several sorts of trees. All this drift-wood about the mouths of rivers, on the north coast of America, appears to be brought down by those rivers from the interior of America: but from the occurrence of many floating trees to the southward of Kamchatka, and from other circumstances, it is probable that much of the drift-wood, found at a distance from the mouths of rivers, comes very far from the southward. (p. 575—580).

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* P. 522.

† Conversations on Vegetable Physiology, vol. ii. p. 232.

Nor does the benefit, arising from vegetable forms of fuel, terminate with their consumption. The residuary ashes are useful, as a manure for the land, on account of the alkaline matter which they contain: and that alkaline matter is also to many a poor peasant a substitute for soap; the lixivium, or ley, which may be obtained by filtering water through the ashes, owing its detergent quality to the alkali which it has dissolved in its passage. In those parts of the world indeed, as in North America, for instance, where it is requisite to clear the land of wood, for the purpose of bringing it into cultivation, the ashes of the forests, which are necessarily burned for this purpose, afford an enormous quantity of alkaline residuum; and this is the source of much of that alkali of commerce, which, from having been obtained by evaporation of its solution in iron pans or pots, is commonly known under the name of *potash.*

That other alkali of commerce, called *soda*, is derived from a similar, though indeed a much more humble source; for, in this case, the alkali does not result from the combustion of stately and aboriginal forests, but from the combustion of heaps of sea-weed; which, in various parts of the coast of Europe, has been collected from the surfaces of the adjoining rocks.*

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* In some instances loose stones are intentionally placed on the sea-beach for the purpose of affording a substratum for the growth of various sea-plants, which attach themselves to the stones so placed.

CHAPTER IX.

ADAPTATION OF ANIMALS TO THE PHYSICAL CONDITION OF MAN.

Section I.

General Observations on the Animal Kingdom.

The same remark may be made with regard to the general utility of animals, which has been made in the case of vegetables: for we have sufficient reason for believing, that, among the myriads of species of animals which exist upon the face of the earth, there is not one which does not act an important part in the economy of nature.* And yet, if it be correctly stated that out of about a hundred thousand species of animals, the number supposed to have been hitherto discovered, eighty thousand are of the class of insects;† it will be evident that the mass of mankind is ignorant of the very existence of nearly four fifths of the whole animal kingdom: for, with the exception of the fly, the bee, the wasp, the ant, and perhaps ten or twelve more species, few but professed naturalists are acquainted with the specific differences of this class of animals; so small are they in size, and so apparently insignificant to a common observer. But, if we have reason for believing that not a single animal species exists without its use in the general economy of nature, we have a certainty that there are many, the absence of which would be almost incompatible with the continuance of the existence of the human race. If, for instance, the duties of the shepherd and herdsman could no longer be exercised, in consequence of the extinction of the two species of which they have now respectively the care, into what misery would not the population of a great part of the world be plunged, cut off at once from some of the most substantial forms of animal food, and the most general and effectual sources of clothing!

And, if we consider the subject in another point of view, how fitly are the natures of these species, from the individuals of which such immense advantage accrues to man, accommodated to that end! If, for instance, the sheep and the ox were carnivorous, instead of herbivorous, how could the species be preserved: or, supposing for a moment that a sufficient quantity of animal food could be procured for them, under that supposition how could it be conveniently distributed to the flocks and herds scattered over a thousand hills; which now, without any consequent trouble to the shepherd or the herdsman, leisurely crop the grass, as they slowly traverse the surface from their morning to their evening range of pasture.

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* It is the opinion of Mr. Scoresby, (Account of the Arctic Regions, vol. i. p. 179, 180,) that the olive-green colour of the water, observable in many parts of the Greenland sea, is owing to the presence of numberless quantities of very small medusæ and other minute animals. "These small animals," he says, "apparently afford nourishment to the sepiæ, actiniæ, and other mollusca which constitute the food of the whale: thus producing a dependant chain of animal life, one particular link of which being destroyed, the whole must necessarily perish.

† The number is probably greater.

Let us suppose, again, that the horse were to become extinct. In that event how greatly would be in a moment altered the condition of the whole civilized world! for by what other means could there be kept up that general communication, between distant parts of the same empire, the rapidity and facility of which contribute at the same time to national prosperity, and to individual wealth and comfort; since that recent invention, the steam carriage, though capable of supplying the place of horses along the course of regular roads, would be inapplicable in most other situations? Consider, again, the position of contending armies, whose fate often is determined by the evolutions of united squadrons of this noblest of all the inferior animals; and sometimes even by the speed of the individual charger whose rider conveys the *command* which is to determine those evolutions: or, to descend into less important though not less interesting scenes of domestic life, let us imagine, what we may perhaps have witnessed, the ecstacy of an afflicted parent, who has been enabled by the speed of this all but friend of man to reach the couch, and to receive the dying embraces of a beloved child; or to obtain those means of human aid, which haply may have averted the stroke of impending death.

But in this, as in many similar instances, we can at once perceive (what we may always in reasoning presume) that an alteration in the constitution of any department of nature would be incompatible with that harmony of the whole, the existence of which is evident to all those who are capable of observing and interrogating philosophically the phenomena of creation. And if it should be said that some species of animals have actually become extinct, and others are gradually becoming more and more rare; yet, in such instances, we shall find the fact to be either the result of a providential adjustment, if the expression may be permitted; or, of the original rarity of the species themselves, as in the case of that uncouth bird the dodo;* or, as might possibly happen, with respect to that still more remarkable animal of New Holland, the ornithorhynchus paradoxus: in each of which instances the locality of the species appears to have been always extremely limited.

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* It is not without reason that the epithet *uncouth* has been applied to the dodo; for two distinguised naturalists, in their day, maintained for many years that such a form had never existed, but in the imagination of the painter. One of these individuals however at length had an opportunity of inspecting the well-known specimen of the head of the dodo, which is preserved in the Ashmolean Museum at Oxford; and was then convinced that such a bird had existed. But so far was he from producing the same conviction in the mind of his friend, by the description of the specimen, that he incurred the charge of an intentional deception; and the result was, that an interminable feud arose between them: for though they were attached to the same institution, and lived within its walls, (not indeed without other companions, or absolutely under the same roof, as their prototypes in the Eddystone light-house,) they never again spoke to each other.

On the other hand there are species of animals, which, though so minute, and so far removed from common observation, as to be scarcely known to mankind at large, much less employed for any useful purpose, would yet be productive of great inconvenience were they permitted to increase indefinitely: and hence, although they may perhaps previously accomplish some important end in the scheme of nature, they are destined to be the food of other animals, which, being much larger than themselves, necessarily consume them in great quantity. There is hardly a bird, or a reptile, or a fish, the contents of whose stomach would not bear witness to the truth of the assertion just made: and even among quadrupeds there are many species, as the mole, the hedgehog, the manis, and the ant-eater, which, from the nature of their food, are grouped into a distinct family, called *insectivorous.*

Section II.

Geographical Distribution of Animals.

Among the strongest evidences of an intentional adaptation of the external world to the physical condition of man, may be classed the geographical distribution of animals, taken in connexion with certain points in their general history. Thus the elephant, which lives exclusively on vegetable food, is found naturally in those climates only, where vegetation is so luxuriantly abundant as easily to meet the large supply, which numerous individuals of such enormous bulk require: and then the tractability and docility of the animal are such, that its amazing strength may be easily directed to forward the purposes of man; and often is so directed, in the conduct of military operations, as well as on various ordinary occasions: and lastly, the increase of the species advances slowly; for, in by far the greater number of instances, only one individual is produced at a birth. Now had the elephant been equally adapted to colder climates, where vegetation is comparatively scant, the difficulty of supporting the individual animals in such climates would have diminished the value of the species: or, were elephants as intractable and indocile, as they are the reverse, what destruction would they not be continually dealing around them; witness the scene which took place a few years since in a public menagerie of London; where a company of musketeers was introduced, in order to subdue a single individual of this species, which had become infuriated from accidental circumstances! Or, lastly, had the elephant been as prolific as the swine, (and it should be observed that they are branches of the same natural order,) how could the increased numbers of individuals have been maintained, in the case of a species which is not naturally capable of emigrating to a different climate?

SECTION III.

The Camel.

OF all animals, the camel perhaps is most exactly adapted both to those peculiar regions of the earth in which it is principally, if not exclusively, found; and to those purposes for which it is usually employed by man: to whose wants indeed it is so completely accommodated, and apparently so incapable of existing without his superintendence, that while on the one hand we find the camel described in the earliest records of history, and in every subsequent period, as in a state of subjugation to man, and employed for precisely the same purposes as at the present day; on the other hand, it does not appear that the species has ever existed in a wild or independent state.

With scarcely any natural means of defence, and nearly useless in the scheme of creation, (as far as we can judge,) unless as the slave of man, it forms a remarkable parallel to the sheep, the ox, and other of the ruminating species; which are also rarely, if ever, found, but under the protection of man, and to that protection alone are indebted, indeed, for their existence as a distinct species. Let us compare then the form, and structure, and moral qualities of the camel, with the local character of the regions in which it is principally found; and with the nature of the services exacted of it by man.

The sandy deserts of Arabia are the classical country of the camel; but it is also extensively employed in various other parts of Asia, and in the north of Africa: and the constant communication that exists between the tribes which border on the intervening sea of sand, could only be maintained by an animal possessing such qualities as characterise the camel—"the ship of the desert," as it has emphatically been called. Laden with the various kinds of merchandise which are the object of commerce in that region of the world, and of which a part often passes from the most easterly countries of Asia to the extreme limits of western Europe, and from thence even across the Atlantic to America, this extraordinary animal pursues its steady course over burning sands during many successive weeks. And not only is it satisfied with the scanty herbage which it gathers by the way; but often passes many days without meeting with a single spring of water in which to slake its thirst.

In explanation of its fitness as a beast of burden, for such desert tracts of sand, its feet and its stomach are the points in its structure which are principally calculated to arrest our attention: and its feet are not less remarkably accommodated to the road over which it travels, than is the structure of its stomach to the drought of the region through which that road passes. The foot of the camel, in fact, is so formed that the animal would be incapable of travelling, with any ease or steadiness, over either a rough or a stony surface; and equally incapable is it of travelling for any long continuance over moist ground, in consequence of the inflammation produced in its limbs from the effect of moisture. It is observed, by Cuvier, that these circumstances in its physical history, and not the incapability of bearing a colder temperature, account for the fact, that, while the sheep, the ox, the dog, the horse, and some other species, have accompanied the migrations of man, from his aboriginal seat in central Asia to every habitable part of the globe, the camel still adheres to the desert.

And now observe how its interior structure meets the difficulty of region, where water is rarely found. As in the case of all other animals which ruminate or chew the cud, the stomach of the camel consists of several different compartments; of which one is divided into numerous distinct cells, capable of collectively containing such a quantity of water, as is sufficient for the ordinary comsumption of the animal during many days. And, as opportunities occur, the camel instinctively replenishes this reservoir; and is thus enabled to sustain a degree of external drought, which would be destructive to all other animals but such as have a similar structure: nor is any other animal of the old world known to possess this peculiar structure. But we pass to the inhabited regions of the Andes in the new world, we there meet with several species of animals, as the lama, the vigogna, and the alpaca, which, though much smaller than the camel, correspond generally in their anatomy with that animal, and particularly with reference to the structure of the stomach: they resemble also the camel in docility; and, to complete the parallel, they were employed by the aboriginal inhabitants in the new world for the same purposes as the camel in the old.

Of the two species of camel, the Bactrian and Arabian, the latter is that with the history of which we are best acquainted; and though there is reason to believe, that, whatever is said of the qualities of the one might with truth be affirmed of the other also, on the present occasion whatever is said, is referable to the Arabian species.* The camel, then, not only consumes less food than the horse, but can susmore fatigue. A large camel is capable of carrying from seven to twelve hundred weight, and travelling with that weight on its back, at the rate of above ten leagues in each day. The small courier camel, carrying no weight, will travel thirty leagues in each day, provided the ground be dry and level. Individuals of each variety will subsist for eight or ten successive days on dry thorny plants; but after this period require more nutritious food, which is usually supplied in the form of dates and various artificial preparations: though, if not so supplied, the camel will patiently continue its course, till nearly the whole of the fat, of which the boss on its back consists, is absorbed; whereby that protuberance becomes, as it were, obliterated.

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* The Bactrian species, which has two bosses on its back, is more peculiar to Tartary and northern Asia. The Arabian, which has only one boss, is not confined to the country from which it is named, but is the same species with that which prevails in northern Africa. As in the case of all domesticated animals the varieties of these two species are numerous: and it is a variety of the Arabian species, of a small height, to which the ancients give the name of *dromedary*, from its employment as a *courier:* but in the magnificent work of St. Hilaire and Cuvier, (Hist. Nat. de Mammifères,) the term *dromedary* is adopted, in a specific sense, for all the varieties of the Arabian camel.

The camel is equally patient of thirst as of hunger: and this happens, no doubt, in consequence of the supply of fluid which it is capable of obtaining from the peculiar reservoir contained in its stomach. It possesses moreover a power and delicacy in the sense of smell, (to that sense at least such a power is most naturally referable,) by which, after having thirsted for seven or eight days, it perceives the existence of water at a very considerable distance: and it manifests this power by running directly to the point where the water exists. It is obvious that this faculty is exerted as much to the benefit of their drivers, and the whole suite of the caravan, as of the camels themselves.

Such are some of the leading advantages derived to man from the physical structure and powers of this animal: nor are those advantages of slight moment which are derived from its docile and patient disposition. It is no slight advantage, for instance, considering the great height of the animal, which usually exceeds six or seven feet, that the camel is easily taught to bend down its body on its limbs, in order to be laden: and, indeed, if the weight to be placed on its back be previously so distributed, as to be balanced on an intervening yoke of a convenient form, it will spontaneously direct its neck under the yoke, and afterwards transfer the weight to its back. St. Hilaire and Cuvier, from whom the substance of much of the preceding account is taken, assert, that, if after having laid down and received the intended freight, the camel should find it inconveniently heavy, it will not rise till a part has been taken off; and that, when fatigued by long travel, it will proceed more readily and easily if the driver sing some familiar tune. This however is a quality not peculiar to the camel.

Considered only thus far in its history, the camel easily stands pre-emiment, as the most useful, among all the species of ruminating animals, in the bodily or mechanical services which it renders to man: it is almost indeed the rival of the horse, even when compared in a general point of view; but more than its rival in its particular arena, the desert. The reindeer assists the individual wants of the Laplander by conveying his sledge over the frozen surface of the snow: and the ox, on a more enlarged scale of labour, is employed in some countries in ploughing, or in the draught of heavy weights: but the camel was from time immemorial, up to a comparatively recent period, almost the sole intermedium of the principal part of the commerce of the whole world. Thus the spices and other rich merchandise of the East, being brought to the confines of Arabia, were conveyed on the backs of camels across the desert, and thence finding their way to the trading cities of Phenicia, while they yet flourished—and subsequently, after their destruction or decay, to Alexandria—they were distributed over the continent of Europe; enriching whole nations by the profits of the mere transfer: for thus Venice became not only the mistress of the Adriatic and Mediterranean, but in a measure the arbitress of the whole world—

"And such she was;—her daughters had their dowers
From spoils of nations, and the exhaustless East
Pour'd in her lap all gems in sparkling showers.
In purple was she robed, and of her feast
Monarchs partook, and deem'd their dignity increased."*

And when, in consequence of the discovery of the Cape of Good Hope, Alexandria ceased to be the main emporium of India and Europe, Venice declined in its riches and power; and the Portuguese, the Dutch, and lastly the English, acquired the political influence which Venice had lost: so true is the observation of Sir William Temple, that whatever nation is in possession of the commerce of India must necessarily have a preponderating influence in the affairs of the whole world.†

But, although the route by the Cape has in a great measure superseded that by Alexandria, the commercial intercourse carried on by means of the camel between opposite confines of the African and Asiatic deserts is still sufficiently extensive to make the importance of that animal very considerable: so that even now, as ages and ages since, the riches of an individual are estimated by the number of camels he may possess: and he still uses his camels either in war, or for the transport of merchandise, or for the purpose of selling them.‡

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* Childe Harold, Canto IV. Stanza 2.

† For an account of the traffic between India and Europe, see Niebuhr, Descript. de l'Arabie, p. 246, &c.

‡ It cannot be considered an irrelevant, and certainly not in itself an uninteresting digression, here to observe, that there was a period in the commercial history of England, within the last century even, when the horse served the purpose in this island, which the camel serves in Arabia and other parts of the world: and a distinct trade then existed, that of the *packer;* the occupation of which was to make up bales of goods in a form convenient for carriage on the back of the *pack-horse;* and the trace of that mode of conveyance is still to be recognised in the *sign* of many inns in those parts of England where that mode of conveyance was prevalent. The same mode of conveyance is still very extensively employed in the north-eastern parts of the Russian dominions.

But it would be found, upon pursuing the history of the camel, that, while under the point of view which has been just considered, this animal contributes more largely to the advantages of mankind than any other species of the ruminating order, it scarcely is inferior to any one of those species with respect to other advantages on account of which they are principally valuable. Thus the Arab obtains from the camel not only milk, and cheese, and butter, but he ordinarily also eats its flesh, and fabricates its hair into clothing of various kinds. The very refuse indeed of the digested food of the animal is the principal fuel of the desert; and from the smoke of this fuel is obtained the well-known substance called *sal ammoniac*, which is very extensively employed in the arts; and of which indeed, formerly, the greater part met with in commerce was obtained from this source alone, as may be implied from its very name.*

Section IV.

Domestication of Animals.

Nature has implanted a disposition in almost all animals to be domesticated by man; and also a capability of becoming adapted to the various climates into which they accompany him; and this disposition and adaptation necessarily extend the utility of these animals. There is, moreover, a consequent effect of domestication which is obvious to the commonest observer; and which extends still further the benefits arising from the practice. In a state of nature, almost all the individuals of the same species of animals have, at any given period of their life, so close a resemblance to each other in form, size, and colour, that it is difficult to distinguish them at a little distance: but whenever any species has been long domesticated, or subjugated to the dominion of man, we usually find a proportional variety in those points. In proof of the foregoing assertion it will be sufficient to make a comparison between wild and tame rabbits; or between the domestic and wild cat; and to refer to the differences observable in all those animals which are constantly under the care of man, as the horse, the dog, and the ox.

The alteration which is produced in such cases, and which depends partly on climate and food and general regimen, but still more on the intermixture of the breed, is in many instances of the highest utility to man. Suppose for a moment that, in the case of the horse, any one of the existing varieties, the dray-horse for instance, or the Shetland poney, were from henceforth to determine the permanent character of the species; and observe what would

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*** Ammon, an ancient name of that part of the African desert situate to the west of Egypt, supplied formerly much of the sal ammoniac of commerce.**

be the consequence. What a waste of power, and what an inconvenient increase of trouble and expense, both with respect to stable-room and food, would there be in using the dray-horse, where the Shetland pony would be sufficient; and, on the other hand, how ill would the Shetland pony supply the place of the dray-horse, where enormous weights were to be set in motion!

Again, in the case of the dog, were all other varieties of this most useful animal to be annihilated, and only one form to prevail, its value would be proportionally lessened. If no variety of the dog existed but the small spaniel or the terrier, the miserable inhabitant of the north could no longer travel over his native tracts of frozen snow: nor could the victim of Alpine frost in Switzerland be hereafter rescued from a premature death, as he often now is, by the sagacity and strength of the mastiffs of that region. And, in another element, how many a life, which must have been otherwise lost, has been saved from a watery grave by the joint sagacity and powerful strength of the Newfoundland dog! What would the shepherd do without the assistance which he now derives from his faithful companion? Instead of that compact phalanx which we have often seen advancing over the distant downs, under the direction of the shepherd's dog; and from time to time, in obedience to its intelligent commander, still altering its direction in advancing, as steadily as a ship in sail obeys the helm; we should see a confused and scattered multitude, which all the shepherd's skill and activity could hardly restore to order.

Nor let me be accused of inhumanity if I here instance the assistance which is given to man by those varieties of the dog which are principally used in the chace. Those feelings, which would spare the inferior animals unnecessary pain, are ever to be respected in others and cherished in ourselves; as those feelings which delight in cruelty are to be abhorred: but undoubtedly the desire of inflicting pain is not the incentive to the pleasures of the chace; and therefore, with reference to himself, the hunter is free from the charge of cruelty. With respect to the animal which is the object of the chace, the charge of cruelty is reasonably obviated by this highly probable consideration, that man can hardly inflict on the weaker animals a more cruel death than that, to which they are obnoxious by the very law of nature: for, ultimately, they will almost necessarily be hunted and destroyed by beasts of prey; or, if you suppose them to die either of disease or of old age, what misery must they not undergo in enduring this latter period of their life! In fact, unless in the case of acute disease, the occurrence of which in wild animals there is reason to think is extremely rare, they must, through mere helplessness, perish by hunger.

An ethical discussion is to be avoided on the present occasion; and I shall only therefore observe, that, with respect to the infliction of pain on the inferior animals, in the particular case now under consideration, the grand question is the consequent effect on our own moral feelings.* If we are conscious that we are inflicting pain, we shall do right to abstain from what otherwise would be an innocent amusement; for such abstinence will be a legitimate extension of the scriptural precept, "A righteous man regardeth the life of his beast:" and if, by neglecting the suggestions of our original feelings, we have blunted the edge of the moral sense, doubtless we are culpable in a high degree. And this probably was the case in the gladiatorial exhibitions of antiquity; and is equally the case in the disgusting exhibitions of the bull-fight in Spain, and the more vulgar and not less disgusting spectacle of pugilistic engagements, or baiting of the bull, in our own country. But, omitting such palpably indefensible sports, it doubtless may be affirmed as a general truth that the amusements of hunting or of fishing are not accompanied by any consciousness of a wanton infliction of pain. And, although the occasionally concomitant habits of such sports may eventually blunt the benevolent feelings of our nature, we have not the least evidence that there is a necessary tendency in those amusements to produce that lamentable effect. There then remains, in support of the propriety of such amusements, the argument from the healthiness of the stimulus which they communicate to the mind as well as to the body; thus invigorating both: while they act as a present recreation, which in some shape or other is required by all. But if the pursuit of smaller and weaker animals should appear objectionable to any one, there still remain, in other countries at least if not in this, the wolf, the wild boar, and the tiger: and in subduing these, to which no one will probably object, the dog lends most effectual assistance to man. He is indeed of all animals the most undaunted and courageous. Mr. Burchell, who during his long residence in southern Africa had frequent opportunities of witnessing the character of this faithful guardian of man, has asserted to the author of this treatise, that he has, again and again, seen the fiercest and strongest animals shrink from the defiance of the dog; but he never saw the dog shrink from the defiance of any other animal.†

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* The same observation is applicable to philosophical experiments on living animals; respecting experiments of which nature Shakspeare justly observes,

. . . . "Your highness
Shall from this practice but make hard your heart."
CYMBEL. Act I. Sc. 6.

† Linnæus, in enumerating the characters of the lion, makes, by implication, a somewhat similar observation with respect to the dog. "Leo esuriens prædatur equis et aliis majoribus animalibus;—*canibus coercetur.*" (Linn. System. Gmelin. tom. i. p. 76.)

SECTION V.

Animals as a Source of Food for Man.

ALTHOUGH the inhabitants of very warm climates live principally and often entirely on vegetables; in the colder climates animal food usually makes a part of the daily sustenance of all who are not oppressed by poverty: and nature has not only provided amply for this want, but has afforded the easiest means of supplying it. The disposition of those animals, which afford the great bulk of the supply that is required, as the sheep, the ox, and the swine, is such, that they are not only disposed to live gregariously, but are readily brought under obedience, so as to be inoffensive either to the person or property of man: and their docility in this respect is particularly worthy of our attention, because, from the observations of M. Frederic Cuvier, (Mém. du Mus. tom. xiii. p. 419, 420,) it appears that herbivorous animals are not, as is generally supposed, naturally more mild and tractable than the carnivorous; in fact they are by nature less mild and tractable.

The flesh of all those species, which have been above-mentioned, is, generally speaking, acceptable to the human palate; and is in a great measure necessary to the support of those who are habitually exposed to great exertions and fatigue: but there are many occasions on which such food could not with any convenience be obtained, even by those to whom the expense is not a matter of any consideration. In situations for instance which are far removed from any town, there are very few, with the exception of the possessors of extensive landed property, who can be conveniently supplied with animal food from their own flocks and herds: and in the case of the crews of ships, which are accustomed to make long voyages, it would be utterly impossible to find room in any vessel for such a number of live animals, and still less for the food which those animals would require, as would be competent to supply the daily consumption of all on board. But in all these instances the difficulty is obviated by the preservative quality of common salt: for we know that, by the aid of salted provisions, guarded by the regular use of vegetable acids, a ship's crew may be maintained in good health for an indefinite length of time.

And then, with reference to the general question, there are almost all the herbivorous species of birds, together with the auxiliary supply of their eggs; and those numerous species both of river and of sea fish, which contribute very largely to the support of the human race, not solely by affording food, but by affording a lucrative employment to the fisherman. I omit the consideration of the turtle, the lobster, the prawn, the oyster, and a few other species; because the aggregate consumption of such kind of food is comparatively small; and those animals, as articles of food, may be considered rather as luxuries than necessaries.

Of the animals which supply us with food, the flesh or muscular fibre is that part which is most acceptable to the palate: and it is worthy of consideration that the flesh of those animals, of whose living services we stand hourly in need, as the horse and the dog, are so unpalatable that we are not tempted to eat them unless in cases of dreadful necessity. Many individuals however, through poverty, are content, and some by peculiarity of taste are inclined, to feed on the lungs or liver, or other of the viscera of animals. And modern researches and experiments have taught us that even the bones may be rendered digestible, either by the effect of long boiling under a high degree of artificial pressure, as in the apparatus called *Papin's Digester*, or in consequence of the removal of their earthly basis by means of any convenient acid; and we have also learned, from similar sources, that common saw-dust, by certain chemical processes, may be made nutritious: but we may fairly argue, from the provisional care of nature, that mankind will never be generally reduced to such circuitous means of obtaining their necessary food. In the mean time we may console ourselves with the reflection, that in the event of any temporary or local difficulty, we may find a supply of food where antecedently to the researches above-mentioned we should never have dreamed of looking for it. Vitruvius mentions, in speaking of the construction of garden walks, that the fragments of charcoal, which were a common substratum of such walks, had occasionally afforded a most important magazine of fuel in a protracted siege: and in such an emergency the bones of animals might continue a supply of food, after the flesh had been eaten.

SECT. VI.

Manufacture of Sal Ammoniac.

EVEN in the present abundance of animal food the refuse is not wasted; and all that is thrown aside, as unpalatable or indigestible, is subsequently collected, for the purpose of obtaining a material, very extensively employed and of considerable value in the arts, known familiarly under the name of *sal ammoniac*. Perhaps in the whole circle of the arts there is scarcely any process more interesting, if all the attendant circumstances be considered, than the fabrication of this substance: and the interest principally arises from this peculiarity in the nature of the process, that, among the numerous products which are evolved in its different stages, there is scarcely one which is not sufficiently useful to prevent the necessity of its being thrown away.

Any one, who is in the habit of walking much in the streets of London, will frequently see some half-clothed wretched individual stooping down and holding open an apron, into which he throws from time to time pieces of broken bone and other offal, which he has disengaged from the interstices of the stones that form the carriage pavement. The unsightly load thus obtained is conveyed to the sal ammoniac manufactory; and when a sufficient mass of bones has been accumulated from this and other sources, they are thrown into a cauldron of water, and are boiled for the purpose of clearing them of the grease with which they are enveloped: which grease, subsequently collected from the surface of the water on which it floats, is employed in the composition of soap.

The bones thus cleaned are thrown into large retorts, surrounded by burning fuel, and submitted to the process called *destructive distillation;* whereby, in consequence of the application of a sufficient degree of heat, the matter of the bone is resolved into its constituent elements, from which new compounds are formed. Of these, some pass off in the state of vapour or gas, while the fixed principles remain in the retort.

Among the more remarkable products which pass off are carbonic acid gas, commonly known by the name of *fixed air;* and various combinations of hydrogen and carbon, forming different kinds of inflammable air; together with water holding carbonate of ammonia (*salt of hartshorn*) in solution; and a peculiar oil. Of these products, the fixed air and inflammable air are disregarded, and suffered to escape. The oil is employed to feed lamps placed in small chambers, the sides of which become incrusted with the smoke arising from the combustion: which smoke being collected, becomes an article of sale under the name of *lamp black;* a substance of considerable importance as the basis of printing ink, &c.

It would be tedious, and uninteresting to the general reader, to describe all the intermediate steps of the process: and it is sufficient for the present purpose to state that, towards the conclusion of it, two new compounds are formed, namely muriate of ammonia and sulphate of soda: of which the sulphate of soda is separated by the process of crystallization, and is sold to the druggists under the common name of *Glauber's salt;* and the muriate of ammonia, (*sal ammoniac,*) the great object of the whole manufacture, is finally obtained in a separate state by the process called *sublimation.*

The form of the bones, submitted to destructive distillation in this process, is not altered; and the unvolatilized mass, remaining in the retorts, consists of the earthy and saline matter of these bones, blackened by the carbon which is evolved from their animal matter. Exposure to an open fire drives off this carbon, and leaves the bones still unaltered in form, but nearly blanched: and these bones, subsequently reduced to powder, and mixed with a sufficient quantity of water to give them the requisite degree of consistence, are formed into vessels, which are employed in the process of refining gold and silver.

It was stated that, during the destructive distillation of bone, the carbonic acid and inflammable gases are suffered to escape: but of these the latter might be employed in supplying light to gas burners; and then, out of the numerous products of the complicated process which I have been describing, the carbonic acid would be the only substance not employed for some useful purpose.

SECT VII.

Animals as a Source of Clothing, &c. for Man.

THE utility of many of those animals which supply us with food does not terminate in merely that adaptation of them to human wants. From the same animals we are supplied with clothing also; (but this service, indeed, they render to us in common with various other animals which are unfit for food); and, according to the different states of civilization in which mankind exists, that clothing is more or less artificially prepared. Thus while the African or Australian savage scarcely protects his body from exposure by a partial covering of leaves, or the inner bark of trees; and the Esquimaux envelopes his body in the undressed skin of the seal which he has recently killed, supplying also the separate coverings of his head and feet and hands from the same source; the poorest peasant of any civilized part of Europe derives his clothing not only from one but many different species of animals; to say nothing of those occasional parts of his dress which are obtained from the vegetable and mineral kingdom. The ox, the dog, the sheep, the beaver or the rabbit, and the silk-worm, in almost every instance contribute their direct contingent to the apparel of the humblest individual of Europe, who is not absolutely a mendicant: and, with reference to the dress and ornamental appendages of individuals of more elevated rank, to the animals already mentioned may be added the deer, the goat, the camel, the elephant, the ermine, and numerous other animals which supply the various and rich furs of commerce; the ostrich, and many other birds; and even the tortoise, the oyster, and the puny architect of the more beautiful species of coral.

Nor are the advantages which mankind derive from the animal kingdom, with reference to general commerce and the arts and economical purposes of life, of less importance than the foregoing. How many different substances, as leather, and parchment, and glue; and what various instruments, either for common use, or ornament or amusement, are manufactured from skin and horn, and bone and ivory! With respect to the last-mentioned of which substances indeed, it is a highly interesting fact, that the world has not been supplied with it solely from the two still existing species of elephant, but also, and in a very large proportion, from the extinct and fossil species. Under the name of *licorne fossile*, the tusks of the extinct species have for ages been an object of commerce in the Russian dominions: and M. Pallas describes the abundance of these fossil tusks to be such, that they are found in every direction throughout the greater part of north-eastern Russia.

If we only consider the amount of the consumption of wax and honey, of what importance is not that little insect the bee: and the same observation may be made with reference to the silk-worm and the cochineal!

Lastly, for it is necessary to bring the present subject to a close, what immense advantages accrue to commerce and navigation from the traffic in even a very few species of fish, as the whale, the cod, the herring, and the pilchard! so great indeed are those advantages, that the question of the right of fishery on a particular coast has sometimes been the occasion of involving the most powerful nations in expensive wars: for these fisheries, at the same time that they are a source of immense riches to individuals, constitute, as it were, a nursery for the hardiest race of sailors, and thus become of the highest importance in a national point of view.

CHAPTER X.

ADAPTATION OF THE EXTERNAL WORLD TO THE EXERCISE OF THE INTELLECTUAL FACULTIES OF MAN.

Section I.

On the Rise and Progress of Human Knowledge.

In the preceding part of this treatise the physical character and condition of man were first considered; and, afterwards, the adaptation of external nature to the supply of his bodily wants. It remains for us to consider the adaptation of the various objects of the material world to the exercise of his intellectual faculties.

But, in contemplating the connexion which exists between the external world and the exercise of the mind of man, who shall attempt to describe the nature and boundaries of that yet unmeasured plain of knowledge, in which man is constantly either intellectually expatiating, or practically exerting himself? who, without wandering into the mazes of metaphysical speculation—always amusing in the pursuit, but never, perhaps, satisfactory in the result—who shall develope the obscure steps by which science first finds access to the mind? In reflecting indeed on the state of civilized society during its earlier periods, there is nothing more wonderful in the intellectual history of mankind, than the skilful management of many processes in the arts, the true nature of which was not understood till ages and ages afterwards. Thus, although zinc was scarcely known as a distinct metal till about a century since; and, almost within the same period, one of its commonest ores, calamine, was held in so little estimation in Great Britain that it was frequently used merely as ballast for shipping, (Watson's Essays, vol. iv. p. 6.); yet that same ore was used before the time of Aristotle for the purpose of making brass, and to that purpose is principally applied at the present day. The process also of making wine was known in the earliest periods of history; although the principles on which it is produced were not well understood till a few years since.

Another remarkable fact in the history of human science, which, though frequently observed, has not yet been explained, is the occasional arrest of its progress at a point immediately bordering on discoveries which did not take place till many ages subsequently.* This may be affirmed, in a certain sense at least, with respect to glass: for this substance, though very early discovered, hardly came into general use for ordinary purposes till comparatively a very late period. But a more remarkable instance occurs with respect to the art of printing: and whoever looks at the stereotype stamps, as they may be called, which have been discovered at Herculaneum, and other places, will be disposed to allow that the embryo of the art of printing died, as it were, in the birth.†

In order that the external world may be fitted to the just exercise of our intellectual faculties, it is evidently necessary that its phenomena should be presented to our senses with a certain degree of regularity. This is a condition so obvious to a mind capable of reflection, that we find it inculcated, almost in the same terms, by two writers of the most opposite views as to the causes of those phenomena. Thus Lucretius asserts, that the sun and moon, by the constant returns of their light and the regularity of their course, afford to mankind an assurance that day and night, and the various seasons of the year, will recur not only in a definite order, but also for definite periods of duration.* And thus also, but in language and imagery more elevated, and a sublime acknowledgment of the cause, as well as a declaration of the fact, the author of the 19th Psalm affirms, that "the heavens declare the glory of God, and the firmament showeth his handywork. Day unto day uttereth speech, and night unto night showeth knowledge."

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* The substance of the following note, though not directly illustrative of the subject now under consideration, is not irrelevant to it; and is sufficiently curious in itself to justify its introduction to the notice of the reader.

In Dr. Thomson's Annals of Philosophy for 1817, p. 149, is an account of a paper read at the Royal Society, relative to some experiments made on torpedoes at Rochelle, in which it is stated that, where torpedoes abound, boys are in the habit of playing the following trick to those who are not in the secret. They persuade the ignorant boy to pour water in a continued stream upon the torpedo; and the consequence is, that an electrical shock is conveyed, along the stream, to the body of the boy.

Plutarch notices the same fact in almost the same terms. "It is affirmed by those," he says, "who have often made the experiment, that, in pouring water on a live torpedo, the hand of the person who is pouring the water will be sensible of a shock, which has apparently been conveyed through the water to his hand."

Ἔνιοι δὲ ἱστοροῦσι, πεῖραν αὐτῆς ἐπιπλέον λαμβάνοντες, αν ἐκπέση ζῶσα (*Νάρκε*, the Torpedo,) *κατασκεδαννύντες ὕδωρ ἄνωθεν, αἰσθάνεσθαι τοῦ πάθους ἀνατρέχοντος ἐπὶ τὴν κεῖρα, καὶ την ἁφὴν ἀμβλύνοντος, ὡς ἔοικε δια τοῦ ὕδατος τρεπομένου καὶ προπεπονθότος.*

PLUT. MORALIA, Oxon. 4to, 1797, tom. iv. p. 643, 644.

† A very interesting conjectural account of the origin and progress of the arts, and of social life, occurs in the last part of the fifth book of Lucretius.

But it is also necessary to the just exercise of our intellectual faculties, that the senses of men in general should be similarly affected, when acted on by the same causes: for otherwise there would be no stability in our knowledge, as derived from these its most fertile sources. And though, from a peculiarity in original constitution, or from the effect of disease, the sensations of particular individuals may differ, not only in degree but in kind, from those of the world at large; the error is of no moment, since it may at once be corrected by a reference to the common sense of mankind.

If any one should too curiously object that there can be no direct proof of a similarity of impression, from the same object, on the senses of men in general; it might be answered, that neither is there any direct proof to the contrary: while we have many antecedent reasons for believing that there really is such a similarity of impression. The *structure* for instance of the several organs, of taste, smell, hearing, and sight, is essentially the same in all individuals; and the *functions* of those organs may therefore be presumed to be the same: and from the similarity of the natural expression of disgust, which peculiar odours and flavours usually excite in numerous individuals, it cannot be reasonably doubted that their respective senses are similarly affected by those agents.

If, again, any one should further object that we can have no absolutely firm ground for a reliance on the senses themselves, it might fairly be answered, that although, from the time of Pyrrho to that of Berkeley, there have been always *speculative* sceptics with respect to the testimony of the senses, there probably has never been a *practical* sceptic on that point. It is stated in the life of Pyrrho by Diogenes Laertius, that though that philosopher asserted the nonexistence of matter, and pretended therefore to universal indifference, he was sometimes overcome by his feelings, and would then act as other men act on such occasions; and, when reminded of the inconsequence of his conduct with reference to his doctrine, he would excuse himself by asserting, that it is difficult entirely to put off human nature, (ὠς χαλεπὸν εἴη ὁλοσχερως ἐκδῦναι ἄνθρωπον): and it must be confessed that, in this apology, he offered the best comment on the character of his doctrine. And most philosophically does Lucretius* argue, noticing the apparent modifications of form which bodies undergo, in consequence of being viewed at different distances, that, although no satisfactory reason can be given of the real cause of the illusion, it is preferable to assign a false reason, rather than, by a consequent want of reliance on our senses, to overturn those foundations of all belief, on which our safety and life depend.

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* Lib. V. 971—979, and 1435—1438.

We have seen, in the course of the foregoing inquiry, how extensively the various objects of the material world are applicable to the wants and conveniences of man in every stage of society; and we cannot reasonably doubt that they were created for that, as a main purpose, among others to which they are subservient. Such at least was the conclusion of one of the greatest philosophers of antiquity; though unaided by the direct light of revelation. "For what purpose," asks Cicero, "was the great fabric of the universe constructed? was it merely for the purpose of perpetuating the various species of trees and herbs, which are not endued even with sensation?—the supposition is absurd. Or was it for the exclusive use of the inferior animals?—it is not at all more probable that the Deity would have produced so magnificent a structure for the sake of beings, which, although endued with sensation, possess neither speech nor intelligence. For whom then was the world produced? —doubtless for those beings who are alone endued with reason." ("Sin quærat quispiam, cujusnam causa tantarum rerum molitio facta sit: arborumne et herbarum? quæ, quanquam sine sensu sunt, tamen a natura sustinentur; at id quidem absurdem est? An bestiarum? nihilo probabilius, Deos mutarum et nihil intelligentium causa tantum laborasse. Quorum igitur causa quis dixerit effectum esse mundum? Eorum scilicet animantium quæ ratione utuntur."†) Whether the earliest steps in the discovery of the arts of life depend on the effect of divine inspiration, of which the subject of that inspiration is unconscious—to which supposition there does not appear any reasonable objection—or whether they result from the impulse of unassisted reason; it would be fruitless to inquire: but it is interesting to contemplate the similarity of principle which seems to regulate the discoveries of the useful properties of material substances.‡ Man does not appear to possess that kind of instinct which leads him to the selection of a specific sort of material for his nourishment or clothing, or for the construction of his habitation; but, in proportion as he feels new wants, he meditates on the means of gratifying them; and usually perceives, with a quick eye, those qualities in external bodies, which make them capable of being fitted to the end he has in view. This power of perception is peculiarly characteristic of the intellectal faculties of man: and although the inferior animals have, to a certain extent, the same power, with reference to their specific instincts, yet in them it is very limited. The nest of the same bird may be composed, in different years, of somewhat different materials, according to the latitude of her choice; but, with the exception of such a modification, she never varies from or improves upon the original plan: the comparatively unsheltered hovel of the rock, for instance, is never improved into the comfortable cottage of the swallow.

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* Lib. IV. 502—512.

† Cic. de Nat. Deor. lib. II. c. 53.

‡ The following passages, one from Vitruvius, the other from Cicero, are applicable on the present occasion. "The Deity has provided an abundant supply in every part of the world for the necessary wants of man; and has ordained that

It is probably owing to the exercise of the above mentioned power of perception in the human mind, that the instruments and arts of uncivilized life, observable at all periods of history and in all parts of the world, have such a general resemblance; although, in the construction of the one, or the exercise of the other, there cannot have been any communication of knowledge. Compare, for instance, the stone arrow-heads and axes of the ancient Celtic nations, with the similar instruments of the inhabitants of those islands of the Pacific Ocean which were not discovered till the last century. The following fact, and accompanying remark, may be mentioned, in illustration of the present part of the subject. Captain Beechey, in describing a dead whale which had been wounded by an Esquimaux harpoon, having "a drag attached, made of an inflated seal skin,

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that supply shall be easily attainable: whereas those things which are to be considered in the light of luxuries, as gold and precious stones, are rarely met with, and are procured with difficulty." ("Igitur divina mens, quæ proprie necessaria essent gentibus, non constituit difficilia et cara; uti sunt margaritæ, cæteraque quæ nec corpus nec natura desiderat; sed sine quibus mortalium vita non potest esse tuta, effudit ad manum parata per omnem mundum." Vitruv. Prefat. ad lib. viii.) "In vain had nature created gold and silver, and copper and iron, unless she had at the same time instructed mankind how to discover the repositories of those metals. And, again, in vain had the material been adapted to our wants, unless we understood the method of obtaining it in a separate and perfect state." ("Aurum et argentum, æs, ferrum, frustra natura divina gennisset, nisi eadem docuisset quemadmodum ad eorum venas perveniretur—materia deinde quid juvaret, nisi confectionis ejus fabricam haberemus?" Cicero de Divinat. lib. i. c. 51.) The following passage from Isaiah gives authority to the preceding opinion: "Doth the plowman plow all day, to sow? doth he open and break the clods of his ground? When he hath made plain the face thereof, doth he not cast abroad the fitches, and scatter the cummin, and cast in the principal wheat and the appointed barley and the rye in their place? For his God doth instruct him to discretion, and doth *teach* him." Ch. xxviii. 24—26. And so, when Dr. Thomson considers it as "remarkable that almost all those metals which were known to the ancients to possess malleability." (Thomson's Chemistry, sixth edit. vol. i. p. 325.) it may with propriety be observed that those are exactly the metals, without which society could not have existed.

which had no doubt worried the animal to death," adds this pertinent observation. "Thus, with knowledge just proportioned to their wants, do these untutored barbarians, with their slender boats and limited means, contrive to take the largest animal of the creation." Voyage to the Pacific, p. 270.*

It is probable, then, that there is an instinctive tendency in man to meditate on the nature and properties of those material objects and phenomena which are frequently presented to his view; and subsequently to derive from this meditation the means of applying those objects and phenomena to his wants, whether of a necessary or an artificial character. Thus astronomy was originally cultivated with most success by those who lived in a climate in which an unclouded sky prevailed; navigation, by those who lived on the borders of the ocean; and the general arts of life, by those who inhabited regions characterised by the fertility of their soil, and the abundance and variety of their mineral productions. Of these positions, ancient Egypt, Phenicia, and India are respectively instances: though it is not intended to affirm that an unclouded sky is alone sufficient to produce a tendency towards the cultivation, much less a national superiority in the science of astronomy; nor a vicinity to the sea, an excellence in nautical skill; nor, lastly, a fertile soil and abundance and variety of mineral riches, a correspondent skill in the general arts of life. In every instance it may be presumed that civilisation must have advanced sufficiently to have produced many artificial wants, before individuals feel that powerful stimulus which prompts them to take the full advantage of those resources which nature has placed within their reach. The miserable natives of New Holland, though inhabiting a country as extensive, and in parts as fertile as Europe, have afforded no indications of an approach towards that degree of civilisation which would lead them to discover and apply its resources.

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* The same author observes, in a short sketch of Upper California, that the natives cultivate no land, but subsist entirely "by the chase and upon the spontaneous produce of the earth; acorns, of which there is a great abundance in the country, constituting their principal vegetable food. Of these acorns they procure a supply in the proper season; and, after having baked them, they bruise them between two stones into a paste which will keep unto the following season. The paste, before it is dried, is subjected to several washings in a sieve; which process, they say, deprives it of the bitter taste common to the acorn. We cannot but remark that the great resemblance this custom bears to the method adopted by the South Sea islanders to keep their bread-fruit: nor ought we to fail to notice the manner in which Providence points out to different tribes the same wise means of preserving their food, and providing against a season of scarcity." (p. 399.) A similar reflection will naturally occur to the reader with respect to their mode of decoying deer and ducks: their plan, in the latter instance, differing very little from our own; in the former, being conducted on the principle of the stalking-horse, (p. 399, 400. See also De Bry, vol. i. pl. 25. Descript. of Florida.)

On one occasion, in alluding to the structure of the bow among uncivilized nations, Captain Beechy forcibly reminds the classical reader of a line in the first book of the Iliad: δεινη δὲ κλαγγη γένετ' αργυρέοιο βιοῖο: for, after having said that the Californians string their bows much as we do (p. 402,) he states that the Esquimaux leave the string in contact with about a foot of the wood at each end; while the Californians muffle that part with fur, in order to prevent the *report*, which would betray them, when fighting in ambush. (p. 575.)

But, though it would be a vain and useless speculation to inquire in what way the arts and sciences actually arose, or how it has happened that they were more or less successfully cultivated by different nations, it cannot be either uninteresting or uninstructive to compare the progress which natural science had made in Europe, at a period shortly antecedent to the Christian era, with the state in which it now exists: and such a comparison is in strict accordance with the original intention of this treatise. The materials for this comparison, which will be attempted only on a plan the most general, have been principally derived from Lucretius, and from that work of Aristotle which is entitled, Περὶ Ζώων Ἱστορίας. It should be remembered, however, that there is a broad line of distinction between the mode in which natural science was cultivated by the ancients, and that which has been adopted by the moderns. The ancients, though on many occasions as accurate observers of the obvious phenomena of nature as the moderns, were too hasty in coming to conclusions as to the character and cause of those phenomena; and hence the crude opinions and theories with which their philosophy abounded. But, if we justly consider the precept of Thales, "Know thyself," as a precept of the highest wisdom for our moral conduct, we must, on equally strong grounds, consider it as the highest prerogative of reason, or our intellectual nature, to know the actual extent of its own powers: and it is one of the glories of the philosophy of the present day, that, instead of being ashamed of its own limitations, and consequently prone to hurry into unfounded assumptions for the purpose of hiding its ignorance, it explicitly, and at once, acknowledges the point which for the present must be considered as a barrier to further progress; still however looking forward to the period when the increased accumulation of new facts shall enable it to remove that barrier.

Section II.

Opinions of Lucretius on the Constitution of Matter in general; and on the Nature of Light, Heat, Water, and Air.

In attempting to explain the constitution of the universe, and the general phenomena of nature, Lucretius assumes that matter in its primary form consists of very small and impenetrable particles, which, from their supposed incapability of further division, are called *atoms;* that, from the fortuitous concourse of these atoms, all natural bodies were originally produced; and that into these they are again resolved by those common processes which we are constantly witnessing, as the death and consequent decomposition of vegetables and animals, and the wearing away of the most solid bodies by the effect and exposure to the air, or by the insensible attrition of other bodies: and, lastly, he maintains that these atoms existed from eternity, and are in their essence indestructible.

He asserts as untenable, in fair reasoning, the opinion that there is no term to the divisibility of matter; since, on that supposition, the smallest bodies would consist of an infinite number of parts: and he consequently concludes that those indivisible bodies or atoms must be perfectly solid.* He impugns, as opposed to common sense, the doctrine of Heraclitus that all things are formed from fire,† and also the doctrine of others, that all things are formed from fire or air, or water or earth;‡ or from binary combinations of them, as of air and fire, or of earth and water: and, lastly, he rejects also the doctrine of Empedocles, that all natural substances are produced from the joint union of fire, earth, air, and water.§ And Lucretius, himself supposes that the original atoms of matter may, by a mere variation in the modes of combination, produce all the objects of nature, whether animate or inanimate; illustrating his argument ingeniously by a reference to the fact, that an endless variety of words, of the most different meaning and sound, is produced by various combinations of the same letters.‖

It is not necessary, on the present occasion, to comment on the obviously atheistical character of some of the opinions of Lucretius: but it may safely be affirmed that, although he strains the application of his general argument so as to support a belief in the eternity of matter, denying equally its creation and destructibility; yet the basis of his argument, if confined, as it ought to bave been, to the existing constitution of the earth, rests on a legitimate deduction from the phenomena of nature: for, certainly, there is no reason for believing that a particle of matter has either been lost or added to the earth or to the atmosphere, since their creation. And, in reasoning from the mere phenomena, Lucretius justly asks, if everything which disappears, in consequence of age and apparent decay, is actually destroyed, whence is there a renewal of animal or vegetable life? how do rivers continue to flow?¶ concluding with one of those beautiful illustrations, in which his poem abounds. "It may be said perhaps, that the showers, which sink into the earth and are lost to our sight, apparently perish: but then, from their fertilizing effects on the soil, and their subsequent incorporation with the growing seed, the harvest rises, and the vine and fig-tree flourish. Hence, moreover, animal life in general derives its support; the sportive lamb hence draws its nutriment from its full-fed mother, and wantons round the meads and woods; and hence those woods themselves yearly resounded with the melody of their native tenants. Nor does the effect stop here: for we ourselves ultimately derive our support from the same source; and cities are eventually peopled from the nutriment produced by the very rain which we had fondly supposed to perish. But nothing really perishes; nature producing new forms of matter, from the materials of those which have apparently been destroyed."*

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* Lucret. lib. I. passim.

† Lib. I. 636—639, and 691—700.

‡ Lib. I. 706—712.

§ Lib. I. 713—717.

‖ Lib. I. 817—829.

¶ Lib. I. 226—232.

It would appear, from a very remarkable passage in Lucretius, that some of the philosophers of his day entertained an opinion, which he himself however opposes, that there exists a universal law of gravitation, by which all bodies tend towards the earth as the centre of the universe; that, in consequence of this law, the bodies of those animals which inhabit the opposite, or, as it were, the inferior surface of the earth, are no more capable of falling into the sky which surrounds them, than the animals inhabiting our own, or the relatively upper surface of the earth, are capable of rising into the sky which is placed above them. And, correspondently with the spherical form of the earth, which almost necessarily follows as a corollary from such an exposition of the law of gravitation, the same philosophers argued that, at the same moment when on the opposite surface it is day, with us it is night.†

Although Lucretius, when speaking in general terms of the tendency of all heavy bodies to fall towards the earth, and of the acceleration of motion and increase of force which they acquire in falling, offers such an account of the facts as we might expect from his confused doctrine of atoms, and shows his ignorance of the real character of *positive* gravity; yet of the nature of *relative* or *specific* gravity, that is, of the cause why equal bulks of different bodies are of different weights, he gives the true explanation, by asserting that the heaviest bodies contain most matter, and consequently have fewest pores.‡ That such pores exist not only in wool, and bodies of a similar texture, but even in those which are hard and compact, is proved, he affirms, by the percolation of water through the roofs of caverns; and from the transmission of the food both of animals and plants into their extreme limbs and branches.§

Lucretius considers *light* as a very subtle kind of matter, which, from its tenuity, is capable of inconceivably swift motion; the rapidity of which motion he instances in its nearly instantaneous diffusion through the whole heaven.|| With respect to the connexion of light and colour, he not only affirms that the latter cannot exist without the former; but that the particular colour observable in different bodies is not inherent in those bodies, and that in every instance it is produced by the direction, or other circumstances, under which light impinges either on them, or on the eye of the be-

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* Lib. I. 251—265.

† Lib. I. 1051—1065.

‡ Lib. VI. 334—346. and lib. I. 359—370.

§ Lib. I. 347—354.

|| Lib. IV. 184—190, and 200—202.

holder: and he gives as examples the plumage of the neck of the pigeon, and of the tail of the peacock.* And thus, he adds, the countenances of the audience, and the whole interior of a theatre, closed in with coloured curtains, are tinged with the colour of those curtains.† He instances the foregoing position by a reference to the colour of the sea; which, when viewed in the mass, is blue or green; but, when converted into mere spray, is white.‡ And he argues that colour does not belong to the ultimate constituent parts of bodies, on this ground—that if coloured bodies be reduced to minute particles, the colour vanishes.§

Occasionally he employs terms which, even at the present day, correctly express the fact of the equality of the angle of *incidence* and of *reflexion*: and he graphically describes the effect of *refraction* in altering the line of direction of the rays of light.‖ But, in alluding to the phenomenon of the rainbow, he briefly states some of the circumstances under which it appears; without attempting to account for the mode in which the effect is produced.¶

Lucretius supposes *heat* to be a material substance, because it excites a specific sensation in animal bodies:** and, notwithstanding the obvious alliance between *heat* and light, which is observable in many common phenomena and operations, he conjectures, what has been most unexpectedly ascertained by the experiments of the late Dr. Herschel, that there are rays of heat emitted from the sun, which are distinct from the rays of light emitted from the same source.††

In speaking of the natural sources of heat, he observes, that it is generally produced by rapid motion; and gives as an instance of the heating and even the liquefaction of a leaden bullet, which has been projected through the air with great force and rapidity.‡‡ He also notices friction as a source of heat; instancing the fire which is produced by the mutual attrition of branches of trees.§§ In speaking of compression, as another source of heat, he not only gives the more obvious and probable illustration of lightning, *expressed* or forced out from a condensed cloud:‖‖ but, in mentioning a spring of water observed to be periodically warmer in the night, and colder in the day, he almost anticipates the views of modern chemistry respecting the different capacities of bodies for heat; when, in accounting for the fact, he supposes the heat to be forced by compression, occasioned by diminution of temperature, from the surrounding earth into the water.¶¶ His interpretation indeed of the phenomenon is not correct; but this error does not interfere with the ingenuity of the illustration, or its coincidence with modern hypothesis: and it is remarkable that, even after the lapse of twenty centuries, the real nature of heat is still questionable. We now know that, in such instances as that just mentioned, the apparent difference of temperature depends upon the relative temperature of the surrounding air; water which has been recently drawn up from the well feeling cold in the heat of summer; but warm, during a frost. The fact is, that, being really of a mean temperature throughout the year, it will be greatly beneath the temperature of the air of summer, and therefore will then appear cold; and it will be on the other hand above the temperature of the air of winter, and will therefore at that season appear warm.[*]

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* Lib. II. 794—808.

† Lib. IV. 70—78.

‡ Lib. II. 736—772.

§ Lib. II. 825—832.

‖ Lib. IV. 319—324, and 438—444.

¶ Lib. VI. 524—526.

** Lib. I. 299—304.

†† Lib. V. 609—612.

‡‡ Lib. VI. 176, 177, and 305—307.

§§ Lib. V. 1095—1099.

‖‖ Lib. VI. 270—275.

¶¶ Lib. VI. 861—873.

From various phenomena, as from the drying of linen, or from its becoming damp without a visible accession or exhalation of particles of moisture, Lucretius argues that *water* is capable of existing in the state of an invisible vapour.[†] He asserts also that its constant exhalation from the sea is proved by the corrosion of walls built near the sea-shore, and from the salt taste perceptible in our mouths while walking near the sea;[‡] and that, although this exhalation takes place in a small quantity only, at any given moment and from a given surface, the aggregate quantity, which is the ultimate result, is very great; and, lastly, that in consequence of this exhalation, the sea does not increase in quantity notwithstanding the constant influx of rivers, and the rain that falls into it.[§] He notices moreover and accounts for the equality of the balance, between the quantity that falls into the sea from rain and rivers, and the quantity that is evaporated from the surface of it.[||]

In speaking of *atmospherical air*, Lucretius maintains that, although in its nature invisible, and to all common perception intangible, from various phenomena it may be reasonably inferred, that it is really a tangible, in other words a material, substance. "Thus," he says, "when we observe that the winds, which are evidently nothing more than currents of air, not only drive the clouds in various directions, but violently agitate the ocean; and even occasion the wreck of the largest ships, by dashing them against the rocks; or when, in the form of a hurricane, they snap asunder the stateliest oaks, and lay prostrate in their course the honours of the mountain forest; we cannot doubt that in their mode of action, as well as in the destructive character of their effects, they resemble the inundation of a rapid river; like which, they sweep before them every obstacle, or carry up the heaviest bodies into the atmosphere, in their invisible eddies, with no less ease than the eddies of a rapid stream ingulf whatever comes within their vortex*." He also shows, by a still more refined argument, that the air must be a material substance, because it offers resistance to falling bodies; proving this resistance by the difference in the velocity of falling bodies of different weights: for, were there no resistance in the air, he asserts, and the fact is experimentally shown in modern lectures, that unequal weights, meeting with no impediment or support, would fall with equal velocity†.

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[*] Aristotle, in his history of animals, mentions as a fact, without however offering any explanation of it, that during the night the water is warmer than the air; for in stating that crocodiles commonly remain on the land during the day, but in the water during the night, he adds as a reason, that during the night the water is warmer than the air, (ἀλεεινότερον γάρ ἐστι τῆς αἴθρας. Ed. Bekker. p. 37.)

[†] Lib. I. 306—311.

[‡] Lib. IV. 219—227.

[§] Lib. V. 381—394.

[||] Lib. VI. 607—630.

Lucretius distinctly notices the physical office of the air as a receptacle, and medium of conveyance for sound‡ and odours,§ and the various exhalations continually arising from the surface of the earth‖. But, though he is right in asserting that the skin of animals and the bark of trees are a protection against the action of the air, he is wrong in supposing them to be a protection against the *mechanical* action of that element.¶ The science of chemistry, which had not then arisen, has taught us that such external coverings are a protection against the *chemical* action of the air.

It appears probable, from the preceding statement, that in the age of Lucretius philosophers had formed some reasonable conjectures respecting the nature of light and heat; and that several of the physical phenomena of water and of atmospherical air had been accurately observed, and upon the whole correctly explained by them. And even in a subject of a much more subtle nature, the mutual attraction of the magnet and iron, the explanation of the phenomenon was attempted with a degree of ingenuity quite equal to that, which has marked the reasonings of some of the philosophers of the last and present century, on subjects of a similarly abstruse nature.

In proceeding to account for the attraction of iron by the magnet, Lucretius first describes the well-known experiment of a short chain of iron rings, the several links of which are held together merely by the force of magnetism; the attractive power of which is communicated continuously from the first to the last in the series. He then claims the particular attention of his reader to his proposed explanation of so difficult a subject, by reminding him that, in facts of this kind, many points must be laboriously investigated and established, before a rational solution can be given. Thence, assuming that from all bodies minute particles are constantly radiating, of which, those from some bodies are disposed to affect one sense; from others, another sense; and that all bodies are porous to a greater or less extent, and are severally indued with their specific qualities, affecting or being affected by different bodies differently; he argues that, from the magnet as from all other bodies, such minute and specific particles are constantly emanating; that this emanation dissipates the air from the space intermediate to the magnet and iron; and that, a partial vacuum being thus formed, the ring is immediately propelled, by the air on the other side of it, towards the magnet, to which it subsequently adheres by an invisible bond of union; and so, in succession, all the other rings are impelled: the adhesion taking place by some process, as insensible as that which unites glue to wood; mortar to stone; or the colouring particles of the purple die, to wool.*

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* Lib. I. 272—295.

† Lib. II. 230—239.

‡ Lib. IV. 561—563, and 572, 573.

§ Lib. IV. 219—222, and 228—230.

‖ Lib. V. 276, 277.

¶ Lib. IV. 930—934.

The observations of Lucretius which relate to the mineral and vegetable kingdoms are too few, and of too general a nature, to justify even a cursory comparison of them with the present state of science in those departments: and though Pliny dedicates a considerable proportion of his Natural History both to minerals and vegetables, there is nothing sufficiently systematic in his method, or approximating to the present state of science, to be of any avail for that purpose. The same remark holds good even with respect to Theophrastus, not only in the case of minerals, but of vegetables also. The ancients had a glimpse indeed of the sexual system of Linnæus, with reference to the *palms;* but show no tendency to a generalization of the observation.

SECTION III.

Opinions of the Ancients on the Organization and Classification of Animals.

IT appears from what has been said in the preceding section, that in mineralogy and botany we scarcely find among the ancients the slightest indications of those comprehensive systems, in the construction of which the last and present centuries have been principally instrumental.

Not so in the animal kingdom. In this branch of science the true principles of classification seem to have been almost as clearly understood in the age of Aristotle, as at the present day: and, in order to enable the reader to judge of the truth of this assertion, I propose to offer a short and cursory analysis of that work of Aristotle which is entitled Περὶ Ζώων Ἱστορίας;† comparing it at the same time with similar modern works, and particularly with that of Cuvier entitled, "Le Règne Animal, distribué d'après son Organization," which was published in Paris in the year 1817, in four octavo volumes.‡

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* Lib. VI. 906—1088.

† It will be convenient here to state, that the edition to which references will be made in the following pages is that of Bekker, Berlin, 1829, 8vo.

‡ A new edition of this work was published in 1829, but the preface of the first is retained without any important alteration, and indeed with scarcely any alteration at all. Nor are the alterations, or additions, which have been made in the body of the work, of such a nature as to affect the present comparison.

I shall not stop to inquire whether the work of Aristotle is to be considered as containing the result of his own observations only, or whether he has collected into one body all that had been observed by others as well as himself; which last supposition, however, is probably the true state of the case. But in order to illustrate the magnitude of such an undertaking, and the difficulties attendant on it, even in the present splendid era of philosophical discovery, I need only refer to the following acknowledgment of Cuvier, Aristotle's great rival in this department of natural science, contained in the Preface of the "Règne Animal." He there at once confesses, with reference to his own work, that it would have been utterly impossible for any insulated individual, however long his life, and however great his leisure, to complete a systematic classification of animals on the principle of conformity of structure (which, it should be observed, is Aristotle's leading principle as well as his own); that he should not even have been enabled to offer the present simple sketch, had not the advantages of his situation compensated for his want of time and talent. Surrounded as he was by so many accomplished Naturalists; deriving information from their works at the moment of their publication; and having as free access to their collections as to his own; a great part of his labour necessarily consisted, he affirms, in the application of so many and such rich materials to his present essay.

He accordingly acknowledges his obligations to Geoffroy, Levaillant, Oppel and Blainville, Lacepede, and Lamarck, in the respective departments of quadrupeds, birds, reptiles, fish, and testaceous animals; all which classes of animals are described in the two first volumes of his work. And he particularly expresses his obligations to Latreille, who furnished him with the entire third volume of the "Règne Animal," containing the arrangement of crustaceous animals (*lobsters*, &c); the arachnida (*spiders*, &c.) and insects.* Of his fourth and last volume he speaks in such brief terms as the nature of its contents requires; for, inasmuch as it only contains a compressed account of those animals whose history is very obscure, either from the minuteness of their size, or from our ignorance of their habits and modes of life, it is necessarily very short in itself, and concise in its details.†

It is clearly immaterial, on the present occasion, whether the work of Aristotle, which we are about to examine, be entirely his own, or only a systematic exposition of the opinions and knowledge of others; for, on either supposition, it is evidently a representation, on the authority of which we may fairly rely, of the general amount of knowledge accessible to the contemporaries of Aristotle, in that department of natural science: and as, with even still greater confidence, we may rely on Cuvier's work, as a similar representation of the existing state of knowledge in the same department, I may safely refer to it as a standard of comparison with reference to the knowledge and opinions of the moderns.

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* Preface, p. ix. x.

† Pref. p. xi.

In attempting to give an account of Aristotle's views, it is prudent to state that it has been collected from numerous and various notices distributed very irregularly throughout the body of his work; so that it is scarcely possible to be confident of having given the correct reference in every instance. It is prudent to make this statement, lest any of my readers should be led, in consequence of an incorrect reference, to doubt the fidelity of the representation here given, from the difficulty of meeting with the original passage. This difficulty is perhaps greater in the case of Aristotle, at least with respect to the work in question, than in the case of most other authors, in consequence of what may be called his Pindaric style of digression; which is occasionally so abrupt as to be at first view ludicrous. Thus, in comparing the kidney of the turtle with that of the ox, he suddenly illustrates his subject by observing that the viscera of the bonassus also (an animal not very like a turtle) resemble those of the ox. (Ἔχει δε καὶ ὁ βόνασος τα ἐντὸς ἅπαντα ὅμοια βοΐ. p. 45.) And, again, in the midst of a whole page descriptive of snakes, when speaking of their cloven tongue, he abruptly says that the seal (an animal not more like a snake, than the bonassus the turtle) also has a cloven tongue. (Ἔχει δε καὶ ἡ φώκη ἐσχισμένην τὴν γλωτταν. p. 48.) It may however be presumed that, in these, as in many other instances, not only of this but of many other of his works, the text has been vitiated or interpolated. Indeed some of the opinions expressed in the work are so opposed to the acknowledged physiological acuteness of its author, that they cannot be consistently admitted to have originated with him: and such, assuredly, is the solution offered in explanation of the physical phenomenon to which allusion is made in the proverb, ἀεὶ Διβύη φέρει τι καινόν: respecting which he says "that, in consequence of the want of rain in Libya, animals of all kinds congregate wherever there is water; and that, being rendered tame by thirst, all those individuals which, though of different species, are nearly of the same size, and which go with young for nearly the same period, breed together and produce new forms."

(Πολυμορφότατα δέ (τὰ ζῷα) ἐν τῇ Λιβύῃ—διὰ γὰρ τὴν ἀνομβρίαν μίσγεσ᾽αι δοκεῖ ἀπαντῶντα πρὸς τὰ ὑδάτια, καὶ τὰ μὴ ὁμόφυλα, καὶ ἐκφέρειν ὧν οἱ χρόνοι οἱ τῆς κνήσεως οἱ αὐτοὶ καὶ τὰ μεγέθη μὴ πολὺ ἀπ᾽ ἀλλήλων· πρὸς ἄλληλα δὲ πραΰνεται δια τὴν τοῦ ποτοῦ χρείαν. p. 248.)

With reference to animal life in general, Aristotle notices the gradual advances made by nature from the state of inanimate matter to that of living beings; whence there arises a difficulty in ascertaining the common boundary of the two divisions. And he then observes that, in the scale of material existence, plants immediately succeed to lifeless forms of matter; and that although among plants the degree of the living power is "various, some being indued with a greater portion of it than others; yet, considered collectively, plants represent as it were a middle term between animals and all other bodies; appearing as indued with life, in comparison with all other forms of matter, but devoid of life in comparison with animals. The change from the vegetable to the animal nature is as gradual, as from inanimate to vegetable matter: for there are some marine productions, of which it is difficult to affirm whether they are animal or vegetable; since they permanently adhere to the spot where they are found, and cannot be separated from it without perishing; and they manifest very obscure, if any, signs of sensation. Indeed the whole class of testaceous animals can scarcely be considered as superior to plants, when compared with those animals which are indued with the power of moving from place to place."

(Οὔτω δ' ἐκ τῶν ἀψύχων εἰς τὰ ζῷα μεταβαίνει κατὰ μικρὸν ἡ φύσις, ὥστε τῇ συνεχείᾳ λανθάνειν τὸ μεθόριον αὐτῶν καὶ τὸ μέσον ποτέρων ἐστίν· μετὰ γὰρ τὸ τῶν ἀψύχων γένος τό τῶν φυτῶν πρῶτόν ἐστιν· καὶ τούτων ἕτερον πρὸς ἕτερον διαφέρει τῷ μᾶλλον δοκεῖν μετέχειν ζωῆς, ὅλον δὲ τὸ γένος πρὸς μὲν τἆλλα σώματα φαίνεται σχεδὸν ὥσπερ ἔμψυχον, πρὸς δὲ τὸ τῶν ζῴων ἄψυχον. ἡ δὲ μετάβασις ἐξ αὐτων εἰς τὰ ζῷα συνεχής ἐστιν—ἔνια γάρ των ἐν τῇ θαλάττῃ διαπορήσειεν ἄν τις πότερον ζῷόν ἐστιν ἢ φυτόν· προσπέφυκε γὰρ, και χωριζομενα πολλὰ διαφθείρεται των τοιούτων—ὅλως δὲ πᾶν τὸ γένος τὸ των ὀστρακοδέρμων φυτοῖς ἔοικε πρὸς τὰ ποθευτικὰ των ζῴων. καὶ περὶ αἰσθήσεως, τὰ μὲν αὐτων οὐδὲ, ἓν σημαίνεται. p. 212, 213.)

Again, if we regard the *substance* of the lower species of marine bodies, though in some instances, as in sea-nettles, it approaches to the character of flesh; in others, as in sponge, it closely resembles a vegetable matter. And, lastly, as different bodies appear to partake, in different degrees, of life itself; so do they differ with respect to the degrees of activity in the functions of life. Plants, for instance, seem to be incapable of effecting much beyond their individual nutrition, and the continuation of their species: and the same observation holds with respect to the lowest species of animals. By the addition of sensibility in different degrees, the pleasure and activity of life are increased; first in the gratification arising from mutual intercourse; and further, in the natural affection which the parent feels for its offspring, and in the care of providing food for it."

(Ἡ δὲ τοῦ σώματος ἐνίων σαρκώδης ἐστὶ φύσις, οἷον τά τε καλούμενα τήθυα καὶ τὸ των ἀκαληφων γένος· ὁ δὲ σπόγγος παντελως ἔοικε τοῖς φυτοῖς. ἀεὶ δὲ κατὰ μικραν διαφορὰν ἕτερα πρὸ ἑτέρων ἤδη φαίνεται μᾶλλον ζωὴν ἔχοντα καὶ κίνησιν· καὶ κατὰ τὰς τοῦ βίου δὲ πράξεις τὸν αὐτὸν ἔχει τρόπον. των τε γὰρ φυτων ἔργον οὐδὲν ἄλλο φαίνεται πλὴν οἷον αὐτὸ ποιῆσαι πάλιν ἕτερον, ὅσα γίνεται διὰ σπέρματος· ὁμοίως δὲ καὶ των ζῴων ἐνίων παρὰ τὴν γένεσιν οὐδὲν ἔστιν ἄλλο λαβεῖν ἔργον—προσούσης δ' αἰσθήσεως ἤδη, περί τε τὴν ὀχείαν διὰ τὴν ἡδονὴν διαφέρουσιν αὐτων οἱ βίοι, καὶ περὶ τοὺς τόκους καὶ τὰς ἐκτροφὰς των τέκνων. p. 213.)

Some animals, then, merely extend their species, after the manner of plants, at stated seasons; and take no care of the individuals produced by them. And even of those animals which provide nourishment for their offspring, the greater number exercise their care for a definite period only; that is, till their young are capable of providing for themselves: after which, they forsake or have no further communication with them. Some indeed, apparently indued with a higher degree of intelligence, enter into a social communion, and establish a kind of polity with their offspring."

(Τὰ μὲν οὖν ἁπλως, ὥσπερ φυτὰ, κατὰ τὰς ὥρας ἀποτελεῖ τὴν οἰκείαν γένεσιν· τὰ δὲ καὶ περὶ τὰς τροφὰς ἐκπονεῖται τῶν τέκνων, ὅταν δ' ἀποτελέσῃ, χωρίζονται καὶ κοινωηιάν οὐδεμίαν ἔτι ποιοῦνται· τα δὲ συνετώτερα καὶ κοινωνοῦντα μνήμης ἐπὶ πλέον καὶ πολιτικώτερον χρῶνται τοῖς ἀπογόνοις. p. 213.)

And he makes a distinction in another part of his treatise between such animals, and those which are simply gregarious; the former being characterised by the disposition to contribute collectively to the completion of some one work; as man, the bee, the ant, &c. (πολιτικα δ' ἐστιν ὧν εν τι καὶ κοινὸν γίνεται πάντων τὸ ἔργον· ὅπερ οὐ πάντα ποιεῖ τὰ ἀγελαῖα. ἔστι δε τοιοῦτον ἄνθρωπος, μέλιττα, σφὴξ, μύρμηξ. p. 4.

With the exception of the opinion that inanimate matter graduates into life, nothing advanced by Aristotle in the foregoing observations, if considered in the light of a general statement, is contradicted or set aside by our present knowledge. For no opinion perhaps is more prevalent, among those who are capable of fairly investigating the characters of natural objects and phenomena, than that there are gradations of excellence in the various forms of matter; although the limits of distinction are often obscure. Who, for instance, that has compared the respective structures and qualities of the bodies, can doubt that the most splendid mineral indicates, humanly speaking, an infinitely less effort of creative and superintending power than the most simple vegetable? In the mineral we find a perfect similarity, or rather sameness, of character, pervading all the integrant particles of the mass; the order of their union being the result of a mere external force, which, having once brought them together, ceases to have any further effect. In the vegetable we find a most curiously arranged system of internal tubes or pores, which attract and separate the elementary principles of the soil and of the atmosphere in which the plant is placed; giving rise to structures the most wonderful, and, if we contemplate different individuals of the vegetable kingdom, more variegated than the mind could have imagined—the bark, the wood, the leaves, and lastly the flowers, fragrant with a thousand odours, and emulating the brightest colours of the rainbow. Or, again, if we compare the character of the vegetable, fixed to its native soil, without any inherent power of moving itself, either totally or partially; insensible to the influence of those agents which beget a succession of new feelings and emotions in animals; how contracted in its sphere of relations must we consider the former body, when compared with the latter; and how incalculably a greater power of creation do the phenomena of animal organization indicate! Gorgeous as are the lilies of the field, so that even Solomon in all his glory was not arrayed like one of these, yet what are they in the effect they produce on the human mind, compared with the lightning of the eagle's eye, or the fire-breathing nostril of the horse? Most assuredly, in our estimation of excellence, the intellectual and moral image will always bear the pre-eminence; and, whether or not the physical conformation may eventually be found to correspond, philosophers have actually classed animals in such an order, that those which manifest the higher degree of intelligence, and of moral feeling, are comparatively higher in the scale.

As instances of the equivocal character of those particular forms of organized matter to which Aristotle alludes, when speaking of the obscure boundary that separates animals from vegetables, *corallines* and substances of that kind may be adduced among animals; and, among vegetables, those green, and in appearance gelatinous *confervæ* which are found in abundance in stagnant ditches during the summer. And these, and similar examples, seem to show that, after a lapse of more than twenty centuries, the difficulty of defining the boundary between animal and vegetable organization still exists; a difficulty which is fully admitted by the principal physiologists of the present day.*

In examining, however, more particularly the preceding opinions of Aristotle, there is one which does not accurately agree with the present state of our knowledge: there is not, namely, that continuity of gradation which he expresses by the term συνέχεια.† There is probably no living philosopher who advocates the opinion that gradual advances may be traced from the state of inanimate matter to that of life: for even Lamarck, who entertains the opinion of a gradation in structure among animals to a very extraordinary extent, considers that the difference between organized and unorganized matter, in other words between living and lifeless matter, is extreme; so that they cannot possibly be ranged in the same line. And he also believes that, however remarkable may be the apparent affinity between plants and animals, they may always be distinguished.‡

But a regular gradation of form cannot even be traced in one and the same kingdom of nature: for, with reference to animals, Cuvier disclaims any attempt to class them so as to form a single series descending gradually from the higher to the lower classes. Such an attempt he thinks absurd; and is far from supposing that, even in a separate class, the last in order are the lowest in the degree of their organization; and still further is he from supposing that the last of a higher class are more highly advanced than the first of the class immediately succeeding. He merely allows that a regularly graduated scale is occasionally observable to a certain extent; and maintains that the universal application of such a principle is inadmissible on any philosophical grounds.* And Lamarck himself agrees with Cuvier in this opinion.

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* See Macleay's Horæ Entomologicæ, p. 191.

† A modern parallel to this opinion may be found in the geological hypothesis that the simplest forms of animal life occur only in the older strata; more and more complicated forms appearing in the more recent formations. The progress of geology has shown that this is not really the case. See Prof. Sedgwick's Address to the Geol. Soc. p. 2.

‡ Lamarck, Philosoph. Zoolog. tom. i. p. 377, 384; and 398, in note 1.

The only formal terms of classification employed by Aristotle are εἶδος and γένος, of the first of which he gives a remarkably precise definition. That definition is really, though not in literal order, as follows:—"an animal *species* is an assemblage of individual animals, in which not only the whole form of any one resembles the whole form of any other, but each part in any one resembles the corresponding part in any other. Thus every horse not only resembles every other horse generally, but the eye or the hoof of every horse resembles the eye or hoof of every other horse. And the same statement is applicable to man and other animals. They are therefore the same in the character of their individual parts."

("Εχει δὲ τῶν ζῴων ἔνια μὲν πάντα τὰ μόρια ταὐτὰ ἀλλήλοις, ἔνια δ' ἑτερα. Ταὐτὰ δὲ τὰ μὲν εἴδει τῶν μορίον ἐστιν, οἷον ἀνθρώπου ῥὶς καὶ οφθαλμὸς ἀνθρώπου ῥινὶ καὶ οφθαλμῷ, καὶ σαρκὶ σαρξ καὶ ὀστῷ ὀστοῦν· τὸν αὐτὸν δὲ τρόπον καὶ ἵππου καὶ τῶν ἄλλων ζῴων, ὅσα τῷ εἴδει ταὐτὰ λέγομεν ἑαυτοῖς· ὁμοίως γὰρ ὥσπερ τὸ ὅλον ἔχει πρὸς τὸ ὅλον, καὶ τῶν μορίων ἔχει ἕκαστον πρὸς ἕκαστον. p. 1.)

In comparing the preceding definition of Aristotle with the corresponding difinition of Cuvier, we find that there is no essential difference. Cuvier says, "Every organized body has, exclusively of the common qualities of its tissue, a peculair or proper form; not only generally and externally, but even in the detail of the structure of each of its parts.† And all the individuals belonging to one of these defined forms constitute what is called a *species*."‡

Aristotle thus defines the term γένος. "A *genus* is an assemblage of individuals, in which any one bears, upon the whole, an obviously perceptible resemblance to any other. Thus birds and fish constitute two distinct genera; each comprehending several species. But the corresponding parts, in the different *species* of the same genus, usually differ in colour, form, number, size, or proportion. In different *genera*, indeed, the difference of corresponding parts occasionally proceeds still further; the only resemblance being that of analogy, as between a scale and a feather; a scale being to a fish, what a feather is to a bird."

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* Règne Animal, pref. p. xx, xxi.

† Chaque corps organisé, outre les qualités communes de son tissu, a une forme propre, non-seulement en général et à l'exterieur, mais jusque dans le détail de la structure de chacune de ses parties. Tom. i. p. 16.

‡ Et tous les êtres appartenans à l'une de ces formes constituent ce que l'on appelle une *espèce*. Tom. i. p. 19.

Τὰ δὲ ταὐτὰ μέν ἐστιν, διαφέρει δε καθ' ὑπεροχὴν καὶ ἔλλειψιν, ὅσων τὸ γένος ἐστὶ ταὐτόν. λέγω δὲ γένος οἷον ὄρνιθα καὶ ἰχθύν· τούτων γὰρ ἑκάτερον ἔχει διαφορὰν κατὰ τὸ γένος, καὶ ἔστιν εἴδη πλείω ἰχθύων καὶ ὀρνίθων. Διαφέρει δὲ σχεδὸν τά πλεῖστα τῶν μορίων ἐν αὐτοῖς παρὰ τὰς τῶν παθημάτων ἐναντιώσεις, οἷον χρώματος καὶ σχήματος, τῷ τὰ μὲν μᾶλλον αὐτὰ πεπονθέναι τὰ δε ἧττον, ἔτι δὲ πλήθει καὶ ὀλιγότητι καὶ μεγέθει καὶ σμικρότητι καὶ ὅλως ὑπεροχῇ καὶ ἐλλείψει. p. 1. 'Αλλ' ὡς εἰπεῖν τὰ πλεῖστα καὶ ἐξ ὧν μερῶν ὁ πᾶς ὄγκος συνέστηκεν, ἢ ταὐτά ἐστιν ἢ διαφέρει τοῖς ἐναντίοις καὶ καθ' ὑπεροχὴν καὶ ἔλλειψιν.—Ἔνια δὲ τῶν ζῴων οὔτε εἴδει τὰ μὸρια ταὐτὰ ἔχει οὔτε καθ' ὑπεροχὴν καὶ ἔλλειψιν, ἀλλὰ κατ' ἀναλογίαν, οἷον πέπονθεν—πρὸς πτερὸν λεπίς· ὃ γὰρ ἐν ὄρνιθι πτερὸν, τοῦτο ἐν ἰχθύϊ ἐστὶ λεπίς. p. 2.

But although Aristotle used the term γένος, in its primary sense, as applicable to an assemblage of different species having a general resemblance to each other; he extends it indefinitely, so that it is practicably applicable to the modern and more comprehensive terms of *tribe*, *family*, *order*, or even *class:* for as we have just now seen, he distinctly applies it to the class of fish, and of birds. And it is remarkable that he sometimes uses the term γένος as synonymous with εἶδος, or even a still lower denomination; implying, that is, merely an accidental variation in a species.

The following are instances of an undefined use of the term γένος. Having spoken of red-blooded and vertebrated animals, he adds, τα δε λοιπα γένη των ζῴων ἔστι μεν τέτταρα διῃρημένα εἰς γένη: (p. 104.) in which passage γένος is first equivalent either to the *species* or to the *genus;* and afterwards to the *order*, or to the *class*, of modern zoologists. In another passage he says, εἰσὶ δε γένη των μελλιττων πλέιω; (p. 287.) where γένος is evidently used as εἶδος.

Aristotle was quite aware of the necessary connexion between the blood, or a fluid analogous to it, and the life of an animal. "Every animal," he says, "possesses a vital fluid, the loss of which occasions its death:" (ἔχει δε και ὑγρότητα πᾶν ζῷον, ἧς στερισκόμενον—φθέιρεται. p. 7.) and as the colour of this fluid in the higher classes of animals is always red, (ἔστι δε τὴν φύσιν τὸ αἷμα—ἔχον—τὸ χρωμα ἐρυθρόν. p. 75.) hence, for the purpose of distinctive description, he assumes the colour as an essential quality; and calls those animals which have red blood ἔναιμα, and those which have not red blood ἄναιμα. And thus he established a fundamental natural division, answering to the red-blooded and white-blooded animals of modern zoology: and it is of great importance, with reference to his principle of classification, to bear in mind that he places the ἔναιμα, or red-blooded animals, in the upper part of his scale.

Aristotle was also aware that there is a natural connexion between the existence of red blood, and of a spine or back-bone, made up of several distinct portions called vertebræ; (πάντα δε τα ζῷα, ὅσα ἔναιμά ἐστιν, ἔχει ῥάχιν, p. 66, σύγκειται δ' ἡ ῥάχις ἐκ σφονδύλων. p. 65.) and he saw, consequently, the coincidence of these two conditions in the classification of animals: and hence we find vertebrated animals occupying the first division in his scale, as well as in the scale of modern naturalists; though, in consequence of his desultory method of treating the subject, it requires some care to ascertain the order of his arrangement.

Aristotle begins his work with some observations on the characters of the different component parts of the bodies of animals (and these are subsequently repeated in a more detailed form,) which forcibly remind us of the *tissues* of modern anatomy:* "of the component parts of animals," he says, "some are of the same texture throughout: of which the most general are the blood, and the blood-vessels—the flesh —bone—skin—membranes—hair—fat, &c.

(Τῶν ἐν τοῖς ζώοις μορίων τὰ μέν ἐστιν ἀσύνθετα, ὅσα διαιρεῖται εἰς ὁμοιομερῆ, p. 1. Τῶν δ' ὁμοιομερῶν κοινότατον μέν ἐστι τὸ αἷμα—καὶ τὸ μοριον ἐν ᾧ πέφυκεν ἐγγίνεσθαι (τοῦτο δε καλεῖται φλὲψ,)—καὶ ἡ σὰρξ—ὀστοῦν—δέρμα, ὑμὴν—τρίχες—πιμελή. p. 55.

He then distributes the several classes of animals into those which have blood, and those which have not blood: and though in the first instance his distribution is very confused, yet, when adjusted by subsequent statements, the order of arrangement is as follows. Among those which have blood, are *man*, *viviparous* and *oviparous quadrupeds*, *birds*, *fish*, *cetaceous animals*, and *serpents*.

(Τὰ μεν ἔναιμα—ἄνθρωπός τε καὶ τὰ ζωοτόκα τῶν τετραπόδων, ἔτι δε καὶ τὰ ᾠοτόκα τῶν τετραπόδων καὶ ὄρνις καὶ ἰχθὺς καὶ κῆτος, καὶ—ὄφις. p. 42.)

Among those which have not blood, are animals naturally divisible into segments, as *insects*; animals of a soft substance throughout, as *cuttle-fish*, &c.; animals having comparatively a soft shell, as *lobsters*, &c.; and those which have a hard shell, as *oysters*, &c.)

("Αλλο δε γένος ἐστὶ τὸ των ὀστρακοδέρμων, ὃ καλεῖται ὄστρεον· ἄλλο τὸ των μαλακοστράκων—οἷον κάραβοι καὶ γένη τινὰ καρκίνων καὶ ἀστακων· ἄλλο τὸ των μαλακίων, οἷον—σηπίαι· ἕτερον το των ἐντόμων. Ταῦτα δε πάντα μέν ἐστιν ἄναιμα. p. 10.

He proceeds then to say, that "after having considered the common attributes and actual differences of animals, we must endeavour to find out the causes of these; for only by a demonstration and comparison of the peculiarities of individuals can we hope to arrive at a natural method of classification."

(Πρωτον τὰς ὑπαρχόυσας διαφορὰς καὶ τὰ συμβεβηκότα πᾶσι λάβωμεν. Μετὰ δε τοῦτο τας αἰτίας τούτων πειρατέον εὑρεῖν. οὕτω γὰρ κατα φύσιν ἐστὶ ποιεῖσθαι τὴν μέθοδον, ὑπαρχούσης τῆς ἱστορίας τῆς περὶ ἕκαστον. p. 11.)

"And, first, we must compare together the several component members of animals; for the chief differences among animals will be found in the presence or absence of particular members, and in their order or position; or in their form, proportion, the analogy of their uses, or the peculiarities of their colour, &c."

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* Anticipations of modern physiological opinions are occasionally observable in Galen also. Thus the following passage clearly contains the germ of Bichât's doctrine of organic sensibility. "In vegetables there is a peculiar power of sensation, by which, though incapable of sight, or hearing, &c. they are capable of distinguishing between those particles of matter which will nourish them, and those that will not; attracting the one, and rejecting the other."

(Ἑτερὸν εστι γένος αισθησεως ἐν τοις φυτοις—οὔτε γαρ των ὁρατων, οὔτε των ακουστικων κ. τ. λ. εχει διαγνωσιν, αλλα μονον των τρεφειν η μη τρεφειν δυναμεων· τα μεν γαρ τρεφειν δυναμενα προς εαυτην ελκουσα κ. τ. λ. μεταβαλλει προς το οικειον της τρεφομενης ουσιας, τα δε μη δυναμενα τρεφειν ου προσιεται.—GALENI OP. Kuhn, vol. iv. p. 764.)

(Ληπτέον δε πρωτον τα μέρη των ζῴων ἐξ ὧν συνέστηκεν. Κατὰ γὰρ ταῦτα μάλιστα καὶ πρῶτα διαφέρει καὶ τὰ ὅλα, ἢ τῷ τὰ μὲν ἔχειν τὰ δὲ μὴ ἔχειν, ἢ τῇ θέσει καὶ τῇ τάξει, ἢ καὶ κατὰ τὰς εἰρημένας πρότερον διαφορὰς, εἴδει καὶ ὑπεροχῇ καὶ ἀναλογίᾳ καὶ τῶν παθημάτων ἐναντιότητι. p. 11.)

In the same philosophical spirit, and in terms not essentially different, Cuvier affirms that, in the attempt to establish a natural classification, he examined one by one all the species that he could procure; and then classed together as a subordinate generic group all those which, resembling each other in the more important parts of their structure, differed only in size, or in colour, or in other points of little importance." (J'ai examiné une à une toutes les espèces que j'ai pu me procurer en nature; j'ai rapproché celles qui ne différaient l'une de l'autre que par la taille, la couleur, ou le nombre de quelques parties peu importantes, et j'en ai fait ce que j'ai nommé un sous-genre. Pref. p. xii.)

In the examination of the component members of animals in general, Aristotle selects man as a standard of comparison; alleging as a reason, that, as merchants estimate the value of foreign coin by a comparison with that of their own country, because best known to them; so in making a classification of animals we naturally employ man as a standard, because we are more familiar with the human form than with that of any other animal.

(Πρῶτον δὲ τὰ τοῦ ἀνθρώπον μέρη ληπτέον· ὥσπερ γὰρ τὰ νομίσματα πρὸς τὸ αὑτοῖς ἕκαστοι γνωριμώτατον δοκιμάζουσιν, οὕτω δὴ καὶ ἐν τοῖς ἄλλοις· ὁ δ' ἄνθρωπος τῶν ζῴων γνωριμώτατον ἡμῖν ἐξ ἀνάγκης ἐστίν. p. 11.)

And, man being admitted as the standard of comparison, it necessarily follows that, as a general rule, viviparous animals, birds, reptiles, and fish, would respectively come next in succession: and that order, as we have just seen, Aristotle actually observes. In one instance, indeed, he for a specific reason inverts the order of arrangement; and, commencing with those animals which least resemble man in their organization; and proceeding with those which bear a nearer and nearer resemblance to him; he terminates his description with man, as having the most complicated structure of all animals.

('Επεὶ δὲ διῄρηται τὰ γένη πρῶτον, τὸν αὐτὸν τρόπον καὶ νῦν πειρατέον ποιεῖσθαι τὴν θεωρίαν· πλὴν τότε μὲν τὴν ἀρχὴν ἐποιούμεθα σκοποῦντες περὶ τῶν μερῶν ἀπ' ἀνθρώπον, νῦν δε περὶ τούτου τελευταῖον λεκτεόν διὰ τὸ πλείστην ἔχειν πραγματείαν. p. 112.)

And he then enumerates the several classes in the following order; "animals having a hard shell; animals having a soft shell; mollusca, or animals of a soft substance throughout; insects; fish; birds; oviparous and viviparous quadrupeds; and man: by inverting which order we arrive at a correct view of his original arrangement."

(Πρῶτον δ' ἀρκτέον ἀπὸ τῶν ὀστρακοδέρμων, μετὰ δὲ ταῦτα περὶ τῶν μαλακοστράκων, καὶ τὰ ἄλλα δὲ τοῦτον τὸν τρόπον ἐφεξῆς· ἔστι δὲ τά τε μαλάκια καὶ τὰ ἔντομα, καὶ μετὰ ταῦτα τὸ τῶν ἰχθύων γένος, το τε ζῳοτόκον καὶ τὸ ᾠοτόκον αὐτῶν, εἶτα τὸ τῶν ορνιθων. μετὰ δὲ ταῦτα περὶ τῶν πεζῶν λεκτέον, ὅσα τε ζῳοτόκα καὶ ὅσα ᾠοτόκα δ' ἐστὶ τῶν τετραποδων ἔνια, καὶ ἄνθρωπος τῶν διπόδων μόνον. p. 112.)

It is remarkable that, from the age of Aristotle to nearly that of Linnæus, no systematic classification of animals was attempted; none, at least, was generally adopted. Soon after the commencement of the last century Linnæus directed his attention to the subject; and distributed the whole animal kingdom into six classes, mammalia, birds, reptiles, fish, insects, and worms: in which distribution Lamarck observes that he improved on Aristotle, first, by using the more distinctive term *mammalia*, and placing the *cetacea* in that class; and, next, by making a distinct class of *reptiles*, and arranging them between birds and fish. If this alteration, which has been subsequently adopted by all other zoologists, be made, Aristotle's arrangement of vertebrated animals agrees with that of the present day. And in distributing all other animals into *four* classes, which Linnæus distributes into *two* only, Aristotle must be considered as having proceeded upon the more philosophical principle; because the species of these animals, taken collectively, are much more numerous, and much more diversified in their form and structure, than the species of vertebrated animals. Lamarck's objection to Aristotle's arrangement, on the ground of its commencing with animals of a more complicated instead of those of a more simple structure, is, for more than one reason, of little weight: for, in asserting that such an arrangement is contrary to the order of nature, he makes a peculiar hypothesis of his own the basis of that assertion; and, with the exception of Lamarck himself, almost if not all modern naturalists, including Cuvier, adopt the same principle of arrangement as that of Aristotle.

Lamarck objects with more justice to the terms ἔναιμα and ἄναιμα, as also to the supposed improvement of some modern naturalists by the substitution of the equivalent terms, *red-blooded* and *white-blooded;* because in the second of those two divisions some species are included, as worms, &c. which have red blood. On this ground Lamarck proposed to divide all animals into those which have, and those which have not, vertebræ; or into *vertebral* and *invertebral* animals.* And he extended the *two* invertebral classes of Linnæus to *five*, and subsequently to *ten*.†

With reference to the classification of Aristotle, as expressed in his first book, it has been occasionally observed by literary men, who were not familiar with the details of his history, that quadrupeds in general and reptiles are excluded. "The most comprehensive groups into which the greater number of animals may be distributed,” he says, “ are these: one, of birds; one, of fish; one, of whales and other cetaceous animals; all of which have blood. There is another group of the ὀστρακοδέρμα; another, of the μαλακόστρακα; another, of the μαλακια; and another, of the ἔντομα; all of which are without blood. Of those animals which do not come within the foregoing arrangement, there are no comprehensive groups; for no individual type comprehends many species: and there is one type which is unique, affording only a single species, namely, man. Some types afford different species without a difference of specific denomination: thus there are red-blooded quadrupeds, of which some are “ viviparous, and others oviparous.”

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* Philos. Zool. tom. i. p. 116, &c.

† Ibid. p. 121, 122.

(Γένη δὲ μέγιστα τῶν ζῴων, εἰς ἃ διήρηται τἄλλα ζῷα, τάδ’ ἐστὶν, ἓν μὲν ὀρνιθων, ἓν δ’ ἰχθύων, ἄλλο δὲ κήτους. Ταῦτα μὲν οὖν πάντα ἔναιμά ἐστιν. ἄλλο δε γένος ἐστὶ τὸ τῶν ὀστρακοδέρμων—ἄλλο τὸ τῶν μαλακοστράκων—ἄλλο τὸ τῶν μαλακίων—ἕτερον τὸ τῶν ἐντὸμων. Ταῦτα δε πάντα μέν ἐστιν ἄναιμα—Τῶν δε λοιπῶν ζῴων οὐκέτι τὰ γένη μεγάλα· οὐ γὰρ περιέχει πολλὰ εἴδη ἓν εἶδος, ἀλλὰ τὸ μέν ἐστιν ἁπλοῦν αὐτὸ οὐκ ἔχον διαφορὰν τὸ εἶδος, οἷον ἄνθρωπος, τὰ δ’ ἔχει μεν, ἀλλ’ ἀνώνυμα τὰ εἴδη. Ἔστι γὰρ τὰ τετράποδα καὶ μὴ πτερωτὰ ἔναιμα μεν πάντα, ἀλλὰ τὰ μεν ζῳοτόκα τὰ δ’ ᾠοτόκα αὐτῶν. p. 10.)

And though there are many species of viviparous quadrupeds, yet they have no collective denomination; but each is distinguished, as in the case of the human species, by its proper name; as the lion, deer, horse, &c. on which account we cannot describe them collectively, but must consider the individual nature and character of each.”

(Τοῦ δε γένους τοῦ τῶν τετραπόδων ζῴων καὶ ζῳοτόκων εἴδη μέν ἐστι πολλὰ, ἀνώνυμα δέ· ἀλλὰ καθ’ εκαστον αὐτῶν ὡς εἰπεῖν, ὥσπερ ἄνθρωπος εἴρηται, λέων, ἔλαφος, ἵππος—Διὸ καὶ χωρὶς λαμβάνοντας ἀνάγκη θεωρεῖν εκάστου τὴν φίσιν αὐτῶν. p. 10.)

It is interesting to observe that even Cuvier occasionally experiences a similar difficulty in his classification; and expresses himself, with reference to the difficulty, in nearly the same terms as Aristotle. Thus, in introducing his third order of the mammalia, called *carnivora*, he says, “ The forms of the different genera of this order are so various, that it is impossible to range them in the same series: they are therefore divided into several families.* And of one of these families, the *marsupialia*, to which the oppossum and kanguroo belong, he observes, that “ the genera of that family might form a distinct *order*, so very peculiar is their structure.† And on another occasion he adds, with respect to this same family, that “ although the various species so closely resemble each other in many points as for a long time to have been classed in one genus only; they yet differ so widely in their feet, and teeth, and organs of digestion, that, considered with reference to those parts, they might be distributed, not into one but several *orders*;*—and might constitute even a separate and parallel *class* of mammalia.†

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* Les Carnassiers.—Leurs formes et les détails de leur organisation varient beaucoup—au point qu’il est impossible de ranger leurs genres sur une meme ligne, et que l’on est obligé d’en former plusieurs familles qui se lient diversement entre elles par des rapports multipliés. tom. i. p. 121.

† Les Marsupiaux—pourraient presque former un ordre à part, tant ils offrent de singularités dans leur économie.” tom. i. p. 169.

In addition to the natural groups, enumerated in the distribution above described, Aristotle refers to a few marine animals which principally belong to the zoophytes of Cuvier, without comprehending them under a distinct name. Of that extensive class of animals, called at the present day *polypes*, which are the fabricators and inhabitants of every variety of coral, he says nothing: and of that still more extensive class, if the term *class* be not too confined, the *animalia infusoria*, he was almost necessarily ignorant; most of the species being microscopic.

It appears, from a few scattered notices, that Aristotle had a faint idea that the specific characters and dispositions of animals might be altered, from the effect of food and other circumstances: (τῶν ζῴων τῶν τετραπίδων πολλὴν αἱ χωραι ποιοῦσι διαφορὰν οὐ μόνον πρὸς τὴν ἄλλην τοῦ σώματος εὐημερίαν ἀλλα καὶ πρὸς τὸ πλεονάκις ὀχεύεσθαι καὶ γεννᾶν. p. 122. Ὅσα μεν οὖν μαλακὰς ἔχει τας τρίχας, εὐβοσίᾳ χρώμενα σκληροτέρας ἴσχει, ὅσα δε σκληρας, μαλακωτέρας καὶ ἐλάττους. Διαφέρουσι δε καὶ κατα τοὺς τόπους τοὺς θερμοτέρους καὶ ψυχροτέρους. p. 68.) Ἐνίοτε γίνεται των μονοχρόων ἐκ μελάνων τε καὶ μελαντέρων λευκα—ἐκ δε των λευκων γενων οὐκ ὦπται εἰς μελαν μεταβάλλον. p. 71.)

And he mentions particularly one instance of this kind, though his reasoning on the occasion is not admissible in the present state of physiological knowledge. In observing that, "as the actions of animals are determined by their natural affections and physical powers, so their moral habits, and even some of their physical characters, are capable of being altered by their actions;" he says, that "the common hen, if she have fought with and vanquished the cock, will begin to crow, and to imitate the cock in various ways; and her comb will increase, and her plumage alter to such a degree as to make it difficult to determine whether she be really a hen: even spurs, though small, will sometimes grow on her legs.

(Ὥσπερ δε τας πράξεις κατα τα πάθη συμβαίνει ποιεῖσθαι πᾶσι τοῖς ζῴοις, οὕτω πάλιν καὶ τα ἤθη μεταβάλλουσι κατα τας πράξεις, πολλάκις δε καὶ των μορίων ἔνια, οἷον ἐπὶ των ὀρνίθων συμβαίνει. Αἵ τε γαρ ἀλεκτορίδες ὅταν νικήσωσι τοὺς ἄρρενας, κοκκύζουσί τε μιμούμεναι τοὺς ἄρρενας καὶ ὀχεύειν ἐπιχειροῦσι, καί τό τε κάλλαιον ἐξαίρεται αὐταῖς καὶ τὸ οὐροπύγιον, ὥστε μὴ ῥαδίως ἂν ἐπιγνωναι ὅτι θήλειαί εἰσιν· ἐνίαις δε καὶ πλῆκτρά τινα μικρα ἐπανέστη. p. 302.)

The fact is nearly as Aristotle states it; and, to a certain extent, similar facts are observable in the human species as well as in other animals; namely, that the peculiar characters of the female are occasionally obscured, with respect both to the physical form and the moral habits. But, in reasoning on the phenomena, Aristotle mistakes the effect for the cause. The circumstance of having fought with the cock is not the determining cause of the change in the external form of the hen: but the alteration itself in the external form is dependent on, or at least coincident with an imperfect developement, or a subsequent alteration, of the internal structure; which imperfect developement or subsequent alteration determines that degree of masculine courage which prompts the hen to fight, and to imitate the male in other actions.

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* Malgré une ressemblance générale de leurs espèces entre elles, tellement frappante, que l'on n'en a fait long-temps qu'un seul genre, elles diffèrent si fort par les dents, par les organes de la digestion et par les pieds, que si l'on s'en tenait rigoureusement à ces caractères, il faudrait les répartir entre divers ordres. p. 170.

† On dirait, en un mot, que les marsupiaux forment une classe distincte, parallèle à celle des quadrupèdes ordinaires. p. 171.

And so it sometimes happens that, in females of the human species, the feminine form is either never originally developed, or, by age or other causes, becomes so much altered as to lose its usual characters; (γυνὴ δε τας ἐπὶ τῷ γενείῳ οὐ φύει τρίχας· πλὴν ἐνίαις γίγνονται ολίγαι, οταν τα καταμήνια στῆ. p. 70.) and, correspondently with these exterior traces of virility, there is often in such cases a masculine temperament of the mind, which marks the character of the virago. And, on the other hand, from analogous causes analogous changes are found to take place in the male of our own species, or of any species nearly resembling our own: for, in such instances, the tone of the voice and the general form of the body acquire a feminine character; and that firmness and resolution, which belong naturally to the male, subside to a greater or less degree into a feminine gentleness.

Aristotle, then, had no philosophical notion of the laws which regulate the occasional variation in the specific form of animals; much less of the limits of that variation: for the accurate developement of which, the scientific world, and more than the scientific world, are deeply indebted to the skilful researches and correct reasonings of Cuvier; whose fame will rest securely on this natural and imperishable basis, when his own and all other artificial systems of classification, for artificial we can see them to be even in the present state of our knowledge, will probably have been overturned by the force of those new views of nature, which must necessarily result from the contemplation of the numerous and varied phenomena which are rapidly accumulating in this department of knowledge. The field, indeed, in which Cuvier has laboured with such advantage to science as well as honour to himself, is the investigation of the conditions which accompany the developement of individual and specific form: and the result of his labours has afforded a splendid instance of the wonderful effect which the powers of the human mind are capable of producing, in a subject apparently of the least intrinsic interest and of the most unpromising aspect. The explanation of his views which I shall now attempt to offer, while it may tend to make known the particular merits of this philosopher to a class of readers, who at present are acquainted with little more of him than his great name, will certainly accord with the general object of this treatise.

In the preliminary discourse of his work entitled "Ossemens Fossiles," he states that the great principle in the study of comparative anatomy is this—that in every animal the several parts have such a mutual relation, both in form and function, that if any part were to undergo an alteration, in even a slight degree, it would be rendered incompatible with the rest; so that if any part were to be changed, all the other parts must undergo a corresponding change: and thus any part, taken separately, is an index of the character of all the rest. This law of the co-relation of parts is indeed so defined, that even a portion of a bone may often serve to verify the species of the animal to which it belonged. (p. xlv.)

We know how successfully Cuvier has applied the foregoing principle in establishing the true character of fossil species, of which the imperfect remains, or fragments of remains, are both few and of rare occurrence. The permanency however of specific character does not hold in every part of the organisation; and hence there is an occasional impediment to the application of the principle: but the variation never proceeds beyond certain limits; and therefore no more interferes, eventually, with the uniformity of the specific character of animals, than the periodical oscillations of the celestial bodies counteract the general regularity of their motions.

We are now therefore to consider the nature of the disturbing cause, if I may borrow that expression for a moment, which occasionally interferes with the uniformity of specific character. And, with respect to specific forms, it may be remarked, that, although it is to a certain extent true that all organised bodies have the power of producing beings resembling themselves, yet circumstances of temperature, and of quantity or quality of food, and other causes, have usually some influence in the developement of the body of each individual; thereby producing some corresponding variation in the form: and, consequently, the resemblance between the parent and offspring is never perfect. But—and this is a fact of the highest importance—there is no ground for believing that such variations proceed beyond certain limits; no ground therefore for believing that any of the above-mentioned circumstances could have produced all the differences perceptible in organised bodies; could have advanced for instance, by a gradual alteration of structure, a lower to a higher species. Experience, on the contrary, founded on an examination of the records of remote antiquity, seems to show that the limits of variation were ever the same that they are now. It appears for instance from the mummies of Egypt,* that the general form, and size, and proportions were the same three thousand years since, that they are at present; as well in various other animals as in man; and in all physiological probability therefore were the same three thousand years before that period: so that we cannot refuse to admit, that certain forms have, without exceeding the limits above described, been perpetuated from the creation.

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* Vid. Cuvier, Oss. Foss. i. Disc. Prelim. p. 75, 80.

From various circumstances, however, as has been already stated, the offspring never exactly resembles the parent; and by the extension of those causes which occasion a difference of character, the variation from the common parent may possibly become so great, and so permanent in individuals of the same species, as to exceed in some respects the difference observable in individuals of different species. Such appears to be the fact, when, in the dog species, we compare the grayhound with the turnspit; or the Newfoundland dog with the Blenheim spaniel: and yet, even in such instances, which perhaps may be considered as comprising the extreme limits of variation, the specific character is never so far obscured, but that a child who had been accustomed to see a variety of dogs, and also of other animals, would recognise the character of the dog in each individual of that species.

It is true, indeed, that it would be difficult not only for a child, but even for the most experienced observer, to define those characters by which the specific resemblance is recognised upon a transient view of the animal. Yet, although not obvious on a superficial examination, nature has not left this point undefinable: for, in almost every instance, the form and number of the bones are so accurately preserved, that, however the colour, or the size and the general form of the body may be altered, we have satisfactory criteria of the species in the points just mentioned. But, of all the constituent parts of the body, this observation holds most eminently with respect to the teeth: and in the case of quadrupeds, which principally constitute the highest class of the animal kingdom, and in which class alone any considerable degree of variation is likely to be observed, we have almost always a ready mode of judging of the identity of specific character by an examination of the teeth; for they in almost every instance have teeth, which are entirely wanting throughout the whole class of birds, and often in reptiles and in fish.

In investigating the remote causes of specific variation, we find that domestication is the most general and extensive; and that the effects are produced principally by the joint operation of the following means, namely, diet, general regimen, and the due selection of individuals for the purpose of breeding.*

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* Burckhardt observes, in his notes on the Bedouins, p. 111, and 139, that in barren parts of the desert of Arabia, or in seasons of scarcity, camels and sheep do not multiply so extensively as in fertile plains and seasons. A similar observation would probably hold good with respect to the ratio of increase among the Tchutzki and other tribes of north-eastern Russia, and the inhabitants of New Holland or any other part of the world where the supply of food is scanty.

See, on this subject, a letter, published by Sir John Sebright in 1809, on the art of improving the breeds of domestic animals.

While animals exist in a state of nature, it does not appear that the circumstances in which they are placed give rise to much variation, even in their external and fugitive characters. A uniformity of size and colour is usually observable in the several individuals of the same species; as in the instances of the wild cat and rabbit. Nor is the character liable to be changed by intercourse among individuals of different species. Although, for instance, the hare and rabbit are so nearly allied in form and size and colour, we never meet with a hybrid or mule of those species.

In domesticated species a variation first in colour, and then in size, usually takes place, to an extent proportional to the degree of domestication. Cats, which are less subjugated to man than horses or dogs, vary little more than in colour; scarcely at all in size. And in horses, on the same principle, there is a less degree of variation than in dogs. In the dog, which is of all species the most domesticated, the variation extends to the production of an additional toe, and corresponding metatarsal bone in the hind foot.* And in the human species, in the individuals of which, from their varied intercourse and modes of living, the limits of variation may antecedently be expected to have the widest range, there are families having six fingers.

In concluding this part of the subject, I would observe that the principle, which we have just now been examining, is of very great importance as to the basis of a physiological argument with reference to the identity of the human species throughout the world. For, inasmuch as all the variations in colour, form, and size, of the different nations of mankind, come within the acknowledged limits of specific variation in the animal kingdom, we have hence satisfactory physiological proof that all the varieties of the human race may have proceeded from one common parent. Of the truth of the general position indeed, of which the human species is a particular instance, the work of Aristotle now under consideration is in itself a strong argument: for, notwithstanding the lapse of ages which has taken place since it was written, the description of many species is so accurate, as to leave no doubt of the identity of those described by Aristotle with those to which the description is applicable at the present day.†

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* Ann. du Mus. tom. xviii. p. 342. pl. 19.

† It can hardly escape observation, or fail to excite surprise, that in the work now under consideration, Aristotle usually contents himself with stating facts: he very rarely reasons on their final causes; thus omitting what Cuvier calls one of the most beautiful and useful points in natural history. The following are, I believe, the only instances in which he deviates from mere description. He observes, when speaking of fish, that a great proportion of the spawn of those animals is destroyed in various ways; and that if this were not the case the species would become too numerous.

(Τὰ μεν πολλὰ ᾠὰ οἱ ἄρρενες ανακαπτουσι, τα δ' ἀπολλυται εν τῷ ὑγρῷ· οσα δ' ἂν εκτεκωσιν εις τους τοπους εις ους ἐκτικτουσι, ταυτα σωζεται· ει γαρ παντα εσωζετο, παμπληθες αν το γενος ην εκαστων. p. 169.)

On another occasion he observes, that though the spring is the general season for

SECTION IV.

On those Animal Forms called Monsters, or Lusus Naturæ.

THE subject of the present section is naturally connected with that of the latter part of the preceding: and, although the occasion neither requires nor would justify even a brief examination of the laws which regulate the formation of monsters, or *lusus naturæ*, as they are often called, especially as they have been lately illustrated by that ardent French physiologist Geoffroy St. Hilaire; it will not be perhaps considered impertinent to make a few observations on those remarkable productions, considered with respect to one of the probable final causes of their existence.

The term *lusus naturæ* is applied to those natural productions, which vary in any remarkable degree, with respect to form, colour, structure, size, &c. from the general character of the individuals of the same species. The term literally taken, implies a sportive effort of the creative power of nature; and for the purpose of general description there is no objection to this term, being, as it now is, familiarized by long continued use. But as we have no ground for supposing that nature, or, to use the more proper expression, that the providence of the Creator ever acts without some wise and beneficial purpose, we must consider the term in a philosophical point of view, as expressing an effect, of the natural cause of which we are ignorant.

What, then, is the real character of those unusual productions which are denominated *lusus naturæ*, or *monsters;* or, in other words, for what end has Providence ordained that such productions should be formed and subjected to our observation? And here, as has been observed in another part of this treatise, it will be found, upon even a cursory examination, that in a *lusus naturæ* the character of the species, however obscured, is never lost. There is no ground, in short, for supposing that nature has ever produced such an individual as a chimera or centaur. And Lucretius's scepticism in this point is justified on truly philosophical principles; on the difference namely of the physical constitution of the horse and of man: the horse at the end of his third year being full-grown, while man is yet almost an infant; and a horse being decrepit in his twenty-fifth or thirtieth year, when man is in his full vigour.*

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propagation, yet occasionally the rule is set aside; where, for instance, the preservation of the offspring is the result.

(Ορμετικώτατα μεν ουν ως επι το παν ειπειν προς την οχειαν την εαρινην ὥραν εστιν· ου μην τα παντα γη ποιείται τον αυτον καιρον της οχειας, αλλα προς την εκτροφην των τεκνων εν τοις καθηκουσι καιροις. p. 181.)

* Sed neque Centauri fuerunt, neque tempore in ullo
Esse queat duplici natura, et corpore bino
Ex alienigenis membris compacta potestas—
Principio, circum tribus actis impiger annis
Floret equus, puer haudquaquam, &c.——Lib. V. 876—889.

In pursuing this investigation, it would be obvious to ask, what are the limits which separate a *lusus naturæ* from the ordinary individuals of the same species? and we shall soon find that these limits are, in the majority of instances, undefinable.

If, indeed, in comparing the several organs, agreement with respect to number be the criterion, the limits are for the most part fixed. Thus the human hand so very generally consists of five fingers, that an instance of an individual having more or less than five fingers would be justly esteemed an instance of a *lusus naturæ.* But even number is not always an acknowledged criterion; for, with respect to the teeth, though thirty-two is the usual number in the human subject, yet the instances of persons having only twenty-eight are so frequent, that we can scarcely class them as deviations from the common law.

But if size, or colour, or form be made the criterion, we evidently cannot then fix the limits; for in all these points there is an endless variety in individuals of the same species: so that it might perhaps be truly asserted, that out of the countless myriads of human beings that inhabit the earth, nay even out of all that have existed since the creation, no two individuals would be found to resemble each other exactly, in even any one of those points. And in this wonderful diversity the infinite power of the Deity is distinctly manifested: for, in the exercise of human skill, the most accomplished artist, as soon as he ceases to copy an actual individual, falls into that general similarity of outline by which we are enabled to ascertain his style upon the first view.

If, in the pursuit of our inquiry, we appeal to the distribution of the internal organs of the body, we shall find, that though with respect to many the position is determinable with considerable precision, yet with respect to others, the smaller veins and arteries, for instance, the variation is endless. But—and this most highly deserves our attention—if we consider the *uses* of the parts with reference to the precision of their position, we shall find, that the position of those is most constant, the uses of which are most important; while the distribution of those parts, the position of which may differ to a considerable extent without inconvenience to the individual, is found to be continually varying.

Now as this law of deviation from the usual structure does not seem at all to depend on the construction of the parts themselves; and as the result is necessarily connected with the well-being, and even the life, possibly, of the individual; we cannot consider this result as the effect of chance, or want of design: for, if chance could be admissible as the cause, why should one class of phenomena be so much more frequent than the other? And with equal or still greater force we may apply the argument to the existence of those productions emphatically called *monsters.* Probably then, or rather assuredly, these anomalous productions may, in addition to other ends, be considered as proofs of a particular or constantly superintending Providence; and, like the storms which occasionally ravage the surface of the earth, may awfully recall to our minds the power of the Deity, while they at the same time convince us, by the rarity of their occurrence, of the merciful beneficence of his nature.

CHAPTER XI.

CONCLUSION.

It has been the immediate object of the preceding treatise to demonstrate the adaptation of the external world to the physical condition of man: and, either in considering him merely as an individual, or as a component member of any stage of society, it may be freely admitted that every step in the investigation has tended to confirm this general conclusion, that—whether from chance, (if any philosophical mind acknowledge the existence of such an agent as chance,) or from deliberate design—a mutual harmony does really exist between the corporeal powers and intellectual faculties of man, and the properties of the various forms of matter which surround him; the material constituents of all nature being as evidently adapted to the supply of the wants of his body, as the contemplation of their causes and relations to the exercise of his mind.

We have seen that from the surrounding atmosphere he is constantly supplied with that respirable part of the air, which alone can support the breath of life; and which is demanded for that purpose during almost every moment of his existence. We have seen that from the same source are derived those universal and important agents, water and heat and light, which are equally though not so immediately necessary, as air, to the wants of man. We have seen again, that the mineral kingdom, though it does not directly contribute to the support of life, yet in the form of natural soils sustains the growth of every kind of vegetable; and that on the nutriment derived from this source all animal life essentially depends: we have seen that the same source also supplies those various metallic and earthy bodies, the uses of which are most extensive and important in promoting many of the arts of civilized society. And, lastly, that the advantages derivable from the vegetable and animal kingdoms are, eventually, neither of less extent and importance, nor their adaptation to the physical condition of man less obvious, than those of the mineral and atmospherical.

It would have been easy to demonstrate that an equally obvious but infinitely more important harmony exists between the external world, and the moral condition of man, as between that world and his physical condition: but this province had been assigned to others; and all systematic reference to that harmony has therefore been studiously avoided—though the constantly recurring difficulty has been to abstain from such a demonstration.

But, it may possibly be observed, both the physical and moral relations of man are inevitably soon cut short by death: and though, in many instances, societies continue to be benefited through successive ages in consequence of the efforts of individuals, who have long since ceased to live, yet in many instances, on the other hand, the memorial not only of individuals, but of nations also, entirely perishes; and all things apparently proceed, as if those individuals and nations had never existed.

Shall we then, in concluding this treatise, simply admit the existence of that harmony, the illustration of which was its professed object; and in admitting that existence shall we at the same time express our gratitude to that Power, which has thus amply provided for the physical wants of man, and for the developement of his intellectual faculties? That indeed would have been incumbent on us under any circumstances; and without any qualification arising from the partial occurrence either of disease, or famine, or any other form of physical evil.

But, since they, to whom this treatise is addressed, are conscious that some ulterior cause exists for the adaptation of the external world to the nature of man, beyond the transient supply of his physical wants, or even the exercise of his intellectual faculties; to have exhibited the bare fact of that adaptation, without some reference to its final cause, would have been to leave the whole argument without its just conclusion.

Avoiding however the presumption of speculating on the nature of a future state of existence, we may, without any impropriety, assert, on the authority of revelation, that the happiness or misery of that state will depend much on the use we have made of that external world which surrounds us; and will coincide with the prevailing character of those habits which we have contracted in this life.

This then is the sum of the whole argument. The Creator has so adapted the external world to the moral as well as the physical condition of man, and those two conditions act so constantly and reciprocally on each other, that in a comprehensive view of the relation between the external world and man, we cannot easily lose sight of that most important connexion. And, if we extend our views to a future life, we are taught that the moral state, which has been induced by our prevailing animal or intellectual habits in this life, will be continued and perpetuated eternally in the next—"that in the place where the tree falleth, there it shall be"—that "it is appointed unto men once to die; but after this, the judgment."

Have we then, to refer first to our animal wants and desires, have we indulged without restraint in the pleasures of sense; shrinking from every breath of heaven, unless previously tempered with luxurious warmth, and impregnated with the perfumes of the east? Have we weakened our intellectual faculties, and brutalized our moral feelings, by habitual inebriation; abusing that gift of Heaven, which was intended as a restorative of exhausted nature? Instead of simply satisfying the calls of hunger by plain and moderate diet, have we provoked and pampered the appetite by all the luxuries which the animal and vegetable kingdoms can supply, till at length all appetite has been destroyed; pain and disease have been induced; the human form and feature have been lost under a mass of loathsomeness and corruption; and death, long wished for, yet dreaded, has arrived at last? we shall awake hereafter in another world, but in unaltered misery; without the hope of any second offer of release from the impurity and everlasting punishment of sin.

Or, to refer to the intellectual part of our nature, in contemplating for instance the starry firmament, and in calculating the unerring motions of the heavenly bodies, have we been content to characterise the certainty and regularity of those motions as the result of necessity, or of the laws of an undefined agent called *nature?* And in thus failing to acknowledge explicitly the Author of those laws, though not indeed formally denying his existence, have we, like the nations of old, worshipped the creature, rather than the Creator; and bowed down our knee, as it were, to the host of heaven?—we may in that case hereafter suffer the penalty of our intellectual pride, in a mode severely just. The mind, which in this life failed to exercise its highest functions by adoring the Deity in the contemplation of his works, may be forbidden to extend the exercise of those functions in the next; and, while it looks back with unutterable torment to the forfeited pleasures of its former state, may be condemned, with torment infinitely increased, to expatiate eternally through new fields of knowledge, without the capability of even putting the sickle to the boundless harvest which they present.

But if, happily, we have pursued a wiser course; if, with Newton, we have delighted to deduce from the contemplation of the mechanism of the heavenly bodies the power of Him who made them, and who alone sustains and directs their motions; we may, and with faculties infinitely expanded, cultivate with him the same pure pleasures, which even on earth abstracted his desires from earthly wants; and, enraptured with the harmonious movements of those endless systems, which neither our present organs can see, nor our present faculties apprehend, we may continue to be constantly acquiring new knowledge, constantly absorbed in new wonder and adoration of that Power, from whom, both in this world, and in that which is to come, all knowledge, and every other good and perfect gift are alone derived.

APPENDIX.

Having considered in the preceding pages the general opinions of Aristotle respecting the physiology and classification of animals, I propose in this Appendix to make a selection from his descriptions of some natural groups and individual species of animals, for the purpose of comparing them with the corresponding descriptions of Cuvier; confining myself, however, exclusively to the mammalia, which constitute the first class of vertebrated animals. And, as an introduction to that selection, I shall prefix a comparative view of the observations of the same two authors on some points connected with the general physiology of animals; presenting the whole in the form of two parallel columns, as the most convenient mode of exhibiting the comparison. In each column I shall endeavour to give a free but faithful translation of the original passages, followed by the original passages themselves.*

However extensive may have been the information of the ancients in that department of natural science which is now under consideration; and however capable a mind like that of Aristotle must have been of deducing general conclusions from a systematic examination of facts, sufficiently numerous and various, for the purpose of effecting a natural classification of animals, it could not reasonably be expected that, antecedently to the knowledge of the circulation of the blood, and of the true character of respiration, and also of the physiology of the absorbent and nervous systems, a natural classification could have been accomplished on principles so satisfactory as at the present day. And those individuals pay a very absurd homage to antiquity, who, on occasions like the present, would place the pretensions of the ancients upon an equality with those of the moderns: for the question does not regard the original powers of the mind, but the amount of accumulated knowledge on which those powers are to be exercised; and it would indeed be extraordinary if, inverting the analogy of individuals, the world should not be wiser in its old age, than it was in its infancy.

In comparing, then, the zoology of Aristotle with that of the moderns, it has not been my intention to prove that the classification of the one is built upon equally clear and extensive demonstrations as that of the other; but to show, as in harmony with the general object of this treatise, that, even in the very dawn of science, there is frequently sufficient light to guide the mind to at least an approximation to the truth—to a much nearer approximation, indeed, than could have been antecedently expected by those who are not accustomed to reflect philosophically on the uniformity of the laws of nature. Thus, as has been already mentioned, the advancement of science has shown the existence of such a general coincidence and harmony of relation between the several component parts of an individual animal, that even a partial acquaintance with the details of its structure will frequently enable the inquirer to ascertain its true place in the scale of organization. And hence, although Aristotle knew nothing of the circulation of the blood, or of the general physiology of the nervous system, and even comparatively little of the osteology of animals, yet subsequent discoveries have scarcely disturbed the order of his arrangement. He placed the *whale*, for instance, in the same natural division with common quadrupeds, because he saw that like them it is viviparous, and suckles its young, and respires by lungs and not by gills; and with viviparous quadrupeds it is still classed; the circulation of its blood, as well as the arrangement of its nervous system, being essentially the same as in that class of animals. And, notwithstanding the difference of its form, its osteology, which holds an *analogy* throughout with that of quadrupeds, is the same *actually* in a part where it would be least expected: for, with the remarkable exception of the sloth, all viviparous quadrupeds have exactly seven cervical vertebræ, and so has the whale; whereas fish, to the general form of which the whale closely approximates, having no neck, have no cervical vertebræ: and the deficiency of the neck in fish was recognised by Aristotle.*

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* In order to abridge as much as possible the number and length of the extracts, I have occasionally merely stated a conclusion drawn from several separate paragraphs. In such instances I must claim credit for having rightly understood, and fairly represented, the context.

GENERAL PHYSIOLOGY.

Aristotle.	*Cuvier*, tom. I.
In some animals there is a mutual resemblance in all their parts; as the eye of any one man resembles the eye of every other man: and it is the same with respect to the constituent parts of horses, or of any other animals, which are said to be of the same species: for in individuals of the same species, each part resembles its correspondent part as much as the whole resembles the whole.	Every organized body has its peculiar form: not only generally and exteriorly, but even in the detail of the structure of each of its parts; and all the individuals which agree in the detail of their structure are of the same species.
Ἔχει δε τον ζῴων ἔνια μεν παντα τα μόρια ταυτα ἀλλήλοις, ἔνια δ' ἕτερα. ταὐ-	Chaque corps organisé a une forme propre, non-seulement en gé-

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* Αὐχένα δ' οὐδεὶς εχει ἰχθύς. p. 40.

Aristotle.	*Cuvier*, tom. I.
τα δε τα μεν εἴδει των μορίων ἐστὶν, οἷον ἀνθρώπου ῥὶς καὶ ὀφθαλμὸς ἀνθρώπου ῥινὶ καὶ ὀφθαλμῷ, καὶ σαρκὶ σαρξ καὶ ὀστῷ ὀστοῦν· τὸν αὐτὸν δε τρόπον καὶ ἵππου καὶ των ἄλλων ζώων, ὅσα τῷ εἴδει ταὐτα λέγομεν ἑαυτοῖς· ὁμοίως γαρ ὥσπερ τὸ ὅλον ἔχει πρὸς τὸ ὅλον, καὶ των μορίων ἔχει εκαστον πρὸς εκαστον. p. 1.	néral et à l'extérieur, mais jusque dans le détail de la structure de chacune de ses parties, p. 16, et tous les êtres appartenans à l'une de ces formes constituent ce que l'on appelle une espèce. P. 19.
All animals have certain common organs, by means of some of which they lay hold of, and into others of which they convey their food. The organ by which they lay hold of their food is called the mouth; that, into which they convey it, the stomach: but the other parts are called by various names. The form and relative proportions, structure, and position of these parts, are the same in the same species, but vary in different species of animals. Πάντων δ' ἐστὶ των ζώων κοινα μόρια, ᾧ δέχεται τὴν τροφὴν καὶ εἰς ὃ δέχεται·—Καλεῖται δ' ᾗ μεν λαμβάνει, στόμα, εἰς ὃ δε δέχεται, κοιλία· τὸ δε λοιπὸν πολυώνυμόν ἐστιν.—Ταῦτα δ' εστι ταῦτα καὶ ἕτερα κατα τοὺς εἰρημένους τρόπους, ἢ κατ' εἶδος ἢ καθ' ὑπεροχὴν ἢ κατ' ἀναλογίαν ἢ τῇ θέσει διαφέροντα. p. 6.	The leading character of animals is derived from the existence of a reservoir for their food, that is, an intestinal canal, the organization of which varies according to circumstances. De là (le réservoir d'alimens) dérive le premier caractère des animaux, ou leur cavité intestinale. L'organisation de cette cavité et de ses appartenances a dû varier selon la nature des alimens. P. 21, 22.
In addition to the mouth and stomach, most animals have other common parts by which they exclude the refuse of their food: but in some animals these parts are wanting. Μετα δε ταῦτα ἄλλα κοινα μόρια ἔχει τα πλεῖστα των ζώως πρὸς τούτοις, ᾗ ἀφίησι τὸ περίττωμα τῆς τροφῆς—οὐ γαρ πασιν ὑπάρχει τοῦτο. p. 6.	The lowest animals have no other outlet for the refuse of their food, than that by which they admit the food itself. Il n'y a que les derniers des animaux où les excrémens ressortent par la bouche, et dont l'intestin ait la forme d'un sac sans issue. P. 41.
There are fibres of a peculiar kind in the blood: by the removal of which that fluid is prevented from coagulating: but if they are not removed, it does coagulate. And through defect of these fibres the blood of the deer and of some other animals does not coagulate.	The blood contains a principle called *fibrine;* which, within a short time after the blood has been withdrawn from the body, manifests itself in the form of membranes or filaments.

Aristotle.	*Cuvier*, tom. I.
Ἔστι δε καί ἄλλο γένος ἰνων, ὃ γίνεται μεν ἐν αἵματι·—ὧν ἐξαιρουμένων ἐκ τοῦ αἵματος οὐ πηγνυται τὸ αἷμα, ἐαν δε μὴ ἐξαιρεθῶσι, πήγνυται. p. 64. Ἐν μεν οὖν τῶ τῶν πλείστων αἵματι ζωων ἔνεισιν, ἐν δε τῷ τῆς ἐλάφου καὶ προκὸς καὶ βουβαλίδος καὶ ἄλλων τινων οὐκ ἔνεισιν ἶνες· διὸ καὶ οὐ πήγνυται αὐτων τὸ αἷμα ὁμοίως τοῖς ἄλλοις, ἀλλα τὸ μεν των ἐλάφων παραπλησίως τῷ των δασυπόδων.* p. 65.	(Le fluide nourricier, ou le sang)—contient la fibrine et la gélatine presque toutes disposées à se contracter et à prendre les formes de membranes ou de filamens qui leur sont propres, du moins suffit-il d'un peu de repos pour qu'elles s'y manifestent. P. 27.
The particular senses are five in number, sight, hearing, smell, taste, and touch. Of these the sense of touch is alone common to all animals; and is so generally diffused over the whole body, that it is not said to reside in any specific part. All animals do not possess all the senses; some possess only a part of them. But no animal is without the fifth sense, that of touch.	The most general external sense is that of touch; its seat is the surface of the whole body. Many animals are without the sense of hearing, and of smell, and of sight. Some have none of the senses except that of touch, which is never wanting.
Εἰσὶ δ' αἱ (αἰσθήσεις) πλεῖσται, καὶ παρ' ας οὐδεμία φαίνεται ἴδιος ἑτέρα, πέντε τὸν ἀριθμὸν, ὄψις, ἀκοὴ, ὄσφρησις, γεῦσις, ἁφή. p. 100. Πᾶσι δε τοῖς ζωοις αἴσθησις μία ὑπάρχει κοινὴ μόνη ἡ ἀφὴ, ὥστε καὶ ἐν ὦ αὔτη μορίῳ γίνεσθαι πέφυκεν, ἀνώνυμόν ἐστιν. p. 7. Οὐ γαρ ὁμοίως πᾶσιν ὑπάρχουσιν (αἰσθήσεις,) ἀλλα τοῖς μεν πᾶσαι τοῖς δ' ἐλάττους. p. 100. Τὴν δε πέμπτην αἴσθησιν τὴν ἁφὴν καλουμένην—πάντ' ἔχει ζῷα. p. 101.	Le sens extérieur le plus général est le toucher; son siège est à la peau, membrane enveloppant le corps entier. P. 36. Beaucoup d'animaux manquent d'oreilles et de narines; plusieurs d'yeux; il y en a qui sont réduits au toucher, lequel ne manque jamais. P. 37.
All animals which draw in and breathe out the air have lungs. Those animals which employ water, analogously to air, in respiration, have gills.	When the element subservient to the process of respiration is the air, the organ of respiration is the lungs: when water, the gills.

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* It is deserving of notice, that the animals whose blood is said not to coagulate are such as are usually killed in hunting; and it is understood by physiologists in general, that excessive exercise and violent mental emotions, both which occur in hunted animals, prevent the blood from coagulating. Two of the species here mentioned by Aristotle (πρὸξ and δασύπους or λαγωος) are mentioned by Homer as commonly hunted:

—αγίνεσκον νέοι ανδρες
Αἶγας ἐπ' ἀγροτέρας, ἠδὲ πρόκας, ἠδὲ λαγωούς. ODYSS. p. 295.

Aristotle.	*Cuvier*, tom. I.
Ὅλως δε πάντα ὅσα τὸν ἀέρα δεχόμενα ἀναπνεῖ καὶ ἐκπνεῖ, πάντ' ἔχει πνεύμονα. p. 43. Τα μεν οὖν ἀνάλογον τῇ ἀναπνοῇ χρώμενα τῷ ὑγρῷ βράγχια ἔχει. p. 215.	Quand cet élément est de l'air, la surface est creuse, et se nomme *poumon;* quand c'est de l'eau, elle est saillante, et s'appelle *branchie.* P. 43.
Animals in general appear to have a certain degree of intellectual power, and some are capable of instruction. Some animals are cautious; some are cunning. Man alone is capable of meditation and reflection. Many animals possess memory: no animal but man is capable of recollection.	Even the most perfect animals are infinitely inferior to man in the intellectual faculties; although it is certain that their intelligence performs similar operations to those of the human mind: and they are capable of instruction. Man has the faculty of associating his general ideas with particular images of a more or less arbitrary character, but easily imprinted in his memory, which serve to recall to him the general ideas which they represent.
Φαίνονται γαρ (τα ζῷα) ἔχοντά τινα δύναμιν—περί τε φρόνησιν καὶ εὐήθσιαν—ἔνια δε κοινωνεῖ τινὸς ἅμα καὶ μαθὴσεως καὶ διδασκαλίας. p. 251. Τα μεν φρόνιμα—τα δ' ἐπὶβουλα·—Βουλευτικὸν δε μόνον ἄνθρωπός ἐστι των ζώων. καὶ μνήμης μεν κα διδαχῆς πολλὰ κοινωνεῖ, ἀναμιμνήσκεσθαι δε οὐδεν ἄλλο δύναται πλὴν ανθρωπος. p. 6.	Les animaux les plus parfaits sont infiniment au-dessous de l'homme pour les facultés intellectuelles, et il est cependant certain que leur intelligence exécute des opérations du même genre—ils acquièrent par l'expérience une certaine connaissance des choses. P. 51, 52. L'homme a la faculté d'associer ses idées générales à des images particulières et plus ou moins arbitraires, aisées à graver dans la mémoire, et qui lui servent á rappeler les idées générales qu'elles représentent. P. 50.
In the great number of animals there are traces of the moral affections of man; for some are mild and some are fierce. And the same thing may be very readily discerned in children, for in them we may perceive the germs of their future habits; and indeed the dispositions of human beings at that early period of life do not differ from those of the inferior animals.	Animals are susceptible of emulation, and jealousy, &c. In short, we may observe in the higher animals a certain degree of the reasoning faculty, which appears nearly the same with that of infants before they have acquired the power of speech.
Ἔνεστι γαρ ἐν τοῖς πλείστοις καὶ των ἄλλων ζῳων ἴχνη των περὶ τὴν ψυχὴν τρόπων, ἅπερ ἐπὶ των ἀνθρώπων ἔχει φανερωτέρας τας διαφοράς. p. 212. Τα	Ils sont susceptibles d'émulation et de jalousie—en un mot, on aperçoit dans les animaux supérieurs un certain degré de raisonnement

Aristotle.	*Cuvier*, tom. I.
μεν γάρ ἐστι πρᾶα—τα δε θυμώδη. p. 6. Φανερώτατον δ' ἐστὶ τὸ τοιοῦτον ἐπὶ τὴν των παίδων ἡλικίαν βλέψασιν· ἐν τούτοις γαρ των μεν ὕστερον ἕξεων ἐσομένων ἔστιν ἰδεῖν οἷον ἴχνη καὶ σπέρματα, διαφέρει δ' οὐθεν ὡς εἰπεῖν ἡ ψυχὴ τῆς των θηρίων ψυχῆς κατα τὸν χρόνον τοῦτον. p. 212.	avec tous ses effets bons et mauvais, et qui paraît être à peu près le même que celui des enfans lorsqu'ils n'ont pas encore appris à parler. P. 52.
As man possesses contrivance, and wisdom, and comprehension; so some animals possess a certain natural power, which, though not the same as, in some respects resembles, those faculties. Ὡς γαρ ἐν ἀνθρώπῳ τέχνη καὶ σοφία καὶ σύνεσις, οὕτως ἐνιοις των ζώων ἐστί τις ἑτέρα τοιαύτη φυσικὴ δύναμις. p. 212.	In a great number of animals there exists a faculty, different from intelligence, which is called *instinct.* Il existe dans un grand nombre d'animaux une faculté différente de l'intelligence; c'est celle qu'on nomme *instinct.* p. 53.
All animals which have red blood have a spine or backbone: but the other parts of the bony system are wanting in some species, and present in others. The spine is the base or origin of the bony system: it is composed of vertebræ, which are all perforated; and extends from the head to the hips: and the cranium is a continuation of its upper or anterior extremity.	The first general division of animals includes all those which have a spine or backbone consisting of separate portions called vertebræ. The animals of this division are called *vertebrated.* They have all of them red blood: their body is composed of a head, trunk, and members: the spine, which is composed of vertebræ, having each an annular perforation, and moveable upon each other, commences at its upper or anterior extremity from the head; the lower or posterior extremity usually terminating in a tail.
Πάντα δε τὰ ζῷα ὅσα ἔναιμά ἐστιν, ἔχει ῥάχιν—τὰ δ' ἄλλα μόρια τῶν ὀστῶν ἐνίοις μέν ἐστιν, ἐνίοις δ' οὐκ ἔστιν. p. 66. Ἀρχὴ δὲ ἡ ῥάχις ἐστὶν ἐν πᾶσι τοῖς ἔχουσιν ὀστᾶ. σύγκειται δ' ἡ ῥάχις ἐκ σφονδύλων, τείνει δ' απὸ τῆς κεφαλῆς μέχρι πρὸς τὰ ἰσχία. οἱ μὲν οὖν σφόνδυλοι πάντες τετρεμένοι εἰσὶν, ἄνω δὲ τὸ τῆς κεφαλῆς ὀστοῦν συνεχές ἐστι τοῖς ἐσχάτοις σφονδύλοις, ὃ καλεῖται κρανίον. p. 65.	Dans la première de ces formes [générales,] qui est celle de l'homme et des animaux qui lui ressemblent le plus, le cerveau, &c. sont renfermés dans une enveloppe osseuse, qui se compose du crâne et des vertèbres. p. 57. Nous appellerons les animaux de cette forme les *animaux vertébrés.* p. 58. Leur sang est toujours rouge. p. 63. Leur corps se compose toujours de la tête, du tronc et des membres. L'épine est composée de vertèbres

Aristotle.	*Cuvier*, tom. I.
	mobiles les unes sur les autres, dont la première porte la tête, et qui ont toutes une partie annulaire. p. 62, 63. Le plus souvent l'épine se prolonge en une queue. p. 63.
Red-blooded animals when in their perfect state have either no extremities, or they have one or two pair. Those animals which have more than two pair are not red-blooded.	Their extremities never exceed two pair in number: sometimes one pair is wanting, sometimes both.
In some animals the corresponding limbs are different in form, but analogous in use. Thus the anterior extremities of birds are neither hands nor feet, but wings. Fish have no limbs, but appendages, called fins, commonly four in number, sometimes two.	The form of the extremities varies according to the uses to which they are to be applied; the anterior extremities being hands, or feet, or wings, or fins; the posterior, feet or fins.
Τὰ μὲν ἔναιμα τυγχάνει ὄντα—ὅσα ἢ ἄποδά ἐστι τέλεα ὄντα (ἄπουν δὲ φύσει ἐστὶν ἔναιμον πεζὸν τὸ τῶν ὄφεων γένος, p. 10.) ἢ δίποδα ἢ τετράποδα. τὰ δ' ἄναιμα—πάνθ' ὅσα πλέιους πόδας ἔχει τεττάρων. p. 7. Ἔνια δὲ τῶν ζῴων οὔτε εἴδει τὰ μόρια ταὐτὰ ἔχεί οὔτε καθ' ὑπεροχὴν καὶ ἔλλειψιν, ἀλλὰ κατ' ἀναλογίαν. p. 2. Χεῖρας δ' οὐδὲ πόδας προσθίους ἔχει (οἱ ὄρνιθες,) ἀλλὰ πτέρυγας ἴδιον πρὸς τὰ ἄλλα ζῷα. p. 38. Αὐχένα δ' οὐδεὶς ἔχει ἰχθὺς, οὐδὲ κῶλον οὐθὲν—ἴδιον δ' ἔχουσι—τὰ πτερῦγια, οἱ μὲν πλεῖστοι τέτταρα, οἱ δὲ προμήκεις δύο. p. 40.	Il n'y a jamais plus de deux paires de membres ; mais elles manquent quelquefois l'une ou l'autre, ou toutes les deux, et prennent des formes relatives aux mouvemens qu'elles doivent exécuter. Les membres antérieurs peuvent être faits en mains, en pieds, en ailes ou en nageoires ; les postérieurs, en pieds ou en nageoires. p. 63.
The red-blooded animals are man, viviparous and oviparous quadrupeds, birds, fish, cetaceous animals, and snakes, &c.	The division of vertebrated animals includes man, the mammalia consisting of viviparous quadrupeds and the cetacea, birds, reptiles of all kinds, many of which, though oviparous, are quadrupeds, and fish.
Ἔστι δὲ ταῦτα (ζῷα ἔναιμα) ἄνθρωπός τε καὶ τὰ ζῳοτόκα τῶν τετραπόδων, ἔτι δὲ καὶ τὰ ᾠοτόκα τῶν τετραπόδων καὶ ὄρνις καὶ ἰχθὺς καὶ κῆτος καὶ—ὄφις. p. 42, 43.	Subdivision des animaux vertebres. L'homme—les singes, &c.—les cétacés—les oiseaux—tortues—serpens—poissons. Tom. i. 67.—ii. 351.

Aristotle.	*Cuvier*, tom. I.
Animals of the largest size are found among those which are red-blooded. All animals which have colourless blood are smaller in size than those which have red blood; with the exception of a few marine animals, as some of the sepiæ.*	Vertebrated animals, all of which have red blood, attain to a much larger size than those whose blood is colourless.
Τούτῳ διαφέρει τὰ μέγιστα γένη πρὸς τὰ λοιπὰ τῶν ἄλλων ζῴων, τῷ τὰ μὲν ἔναιμα τὰ δ' ἄναιμα εἶναι. p. 42. *Πάντα δὲ τὰ ἄναιμα ἐγάττω τὰ μεγέθη ἐστὶ τῶν ἐναίμων ζῴων· πλὴν ὀλίγα ἐν τῇ θαλάττῃ μείζονα ἄναιμά ἐστιν, οἷον τῶν μαλακίων ἔνια.* p. 9.	C'est parmi eux (les animaux vertébrés) que se trouvent les plus grands des animaux. p. 62. Le sang est toujours rouge. p. 63.
All red-blooded animals have the five senses.	Vertebrated animals have always two eyes, two ears, two nostrils, the integuments of the tongue and those of the whole body.
Ἄνθρωπος μεν οὖν—καὶ ὅσα ἔναιμα καὶ ζῳοτόκα, πάντα φαίνεται ἔχοντα ταύτας πάσας (αἰσθήσεις.) p. 100.	Les sens extérieurs sont toujours deux yeux, deux oreilles, deux narines, les tégumens de la langue, et ceux de la totalité du corps. p. 64.

MAMMALIA.

No animal which is not viviparous has breasts: and even of viviparous animals those only have them which produce their young alive at once, without the intervention of an egg.	The animals of the class *mammalia* are essentially viviparous; inasmuch as a direct communication is established between the embryo and the parent immediately after conception.
The milk is not, as the blood is, a fluid which animals possess from their birth, but a subsequent secretion; and is contained in the breasts. And all those animals have breasts which are essentially or directly viviparous; as man, and such quadrupeds as are covered with hair; and also cetaceous animals, as the dolphin, the seal, and the whale.	The new-born offspring is nourished for a time by milk, which is a special and temporary secretion from the mammæ; organs, so exclusively peculiar to this class, as to have determined the distinctive appellation *mammalia*. This class includes all the common viviparous quadrupeds; together with the seal, and the dolphin, and other cetacea.
Οὐθὲν τῶν μὴ ζῳοτοκούντων (ἔχει μαστοὺς,) οὐδὲ τὰ ζῳοτοκοῦντα πάντα ἀλλ' ὅσα εὐθὺς ἐν αὑτοῖς ζῳοτοκεῖ καὶ μὴ	La génération dans tous les mammifères est essentiellement vivipare; c'est-à-dire que le fœtus,

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* See a curious engraving in Montfort, Hist. Nat. des Mollusques, tom. ii. p. 256, epresenting a gigantic sepia grasping a ship and its rigging.

Aristotle.	*Cuvier*, tom. I.
ᾠοτοκεῖ πρῶτον. p. 40. Τῶν δὲ ὄφεων ὁ μὲν ἔχις ζῳοτοκεῖ ἔξω, ἐν αὐτῷ πρῶτον ᾠοτοκήσας. p. 151. Αἷμα ὕγρον σύμφυτόν ἐστι τοῖς ζῴοις· ὑστερόγενες δὲ καὶ ἀποκριμένον ἅπασιν, ὅταν ἐνῇ, ἔνεστι, τὸ γάλα·—ἔχει δε, ὅσα ἔχει τὸ γάλα, ἐν τοῖς μαστοῖς. μαστοὺς δ' ἔχει ὅσα ζῳοτοκεῖ καὶ ἐν αὐτοῖς καὶ ἔξω, οἷον ὅσα τε τρίχας ἔχει, ὥσπερ ἄνθρωπος καὶ ἵππος, καὶ τὰ κήτη, οἷον δελφὶς καὶ φώκη και φάλαινα· καὶ γὰρ ταῦτα μαστοὺς ἔχει καὶ γάλα. p. 77.	immédiatement après la conception, descend dans la matrice, enfermé dans ses enveloppes—qui établissent entre lui et sa mère une communication, d'où il tire sa nourriture. p. 75, 76. Les petits se nourissent pendant quelque temps, après leur naissance, d'une liqueur particulière à cette classe (le lait,) laquelle est produite par les mammelles—qui ont valu à cette classe son nom de mamifères, attendu que lui étant exclusivement propres, elles la distinguent mieux qu'aucun autre caractère extérieur. p. 76. De la classe des mammifères sont l'homme—les singes—le cheval—les phoques—le dauphin—les baleines, &c. p. 79—284.

MAN.

All animals which have limbs resembling those of man, have their legs and thighs and hips sparingly covered with flesh; whereas in man these parts are more fleshy than any other.	The muscles which extend the foot and thigh of man are more powerful than those of any other animal: and hence the calf of the leg is particularly prominent. The part called the pelvis, situate between the hips, is altogether proportionally larger, in man than in any other animal.
Of all animals man has, in proportion to his size, the largest brain; and the smallest interval between his eyes; and the most delicate sense of touch and of taste.	No quadruped has so large a brain as man. His eyes are so placed as to be necessarily directed only forwards. In the delicacy of the sense of taste and touch man excels all other animals.
No animal but man has its breasts in the front of the chest; the elephant, like the human female, has two breasts, but they are placed on the side.	The female breasts are placed in front of the chest.
No animal but man has the faculty of articulate speech; which consists of vowels pronounced by means of the larynx, and of consonants formed by the tongue and	He possesses an advantage peculiar to himself in the organs of voice; for he alone is capable of uttering articulate sounds; a power which apparently depends on the

Aristotle.	*Cuvier*, tom. I.
lips: the dolphin, therefore, which has a voice in consequence of its possessing lungs, and a larynx, cannot articulate, because its tongue is not readily moveable, and it has no lips.	form of his mouth, and the great flexibility of his lips.
Πάντα δὲ τὰ τετράποδα ὀστώδη τὰ σκέλη ἔχει—καὶ ἄσαρκα—ἔστι δὲ καὶ ἀνίσχια——ὁ δὲ ἄνθρωπος τοὐναντίον· σαρκώδη γὰρ ἔχει σχεδὸν μάλιστα τοῦ σώματος τὰ ἰσχία καὶ τοῦς μηροὺς και τὰς κνήμας. p. 29.	Les muscles qui retiennent le pied et la cuisse (de l'homme) dans l'etat d'extension sont plus vigoureux (que ceux d'aucun mammifère); d'où résulte la saillie du mollet et de la fesse—le bassin est plus large. p. 82.
Ἔχει δὲ (ἐγκέφαλον) ἅπαντα ὅσα ἔχει αἷμα—κατὰ μέγεθος δ' ὁμοίως ἔχει ἄνθρωπος πλεῖστον ἐγκέφαλον. p. 19. Τά δ' ὄμματα ἐλαχίστον κατὰ μέγεθος διέστηκεν ἀνθρώπῳ τῶν ζῳων. ἔχει δ' ἀκριβεστάτην ἄνθρωπος τῶν αἰσθήσεων τήν ἁφὴν, δευτέραν δὲ τὴν γεῦσιν. p. 18, 19.	Aucun quadrupède n'approche de lui pour la grandeur et les replis des hémisphères du cerveau. p. 84. Ses deux yeux sont dirigés en avant; il ne voit point de deux côtés à la fois, comme beaucoup de quadrupèdes. La délicatesse de l'odorat doit influer sur celle du goût, et l'homme doit d'ailleurs avoir de l'avantage, á cet égard, au moins sur les animaux dont la langue est revêtue d'écailles; enfin, la finesse de son toucher résulte, et de celle de ses tégumens, &c. p. 85.
Μαστοὺς δ' οὐκ ἔχει οὐθὲν ἐν τῷ πρόσθεν ἀλλ' ἢ ἄνθρωπος· ὁ δ' ἐλέφας ἔχει μεν μαστοὺς δύο, αλλ' οὐκ ἐν τῷ στήθει ἀλλὰ πρός τῷ στήθει. p. 26.	Ses mammelles, au nombre de deux seulement, sont situées sur la poitrine. p. 88.
Τὰ δε ζῳοτόκα καὶ τετράποδα ζῷα ἄλλο ἄλλην ἀφίησι φωνὴν, διάλεκτον δ' οὐδεν ἔχει αλλ' ἴδιον τοῦτ' ἀνθρώπου ἐστίν. (p. 107.) διάλεκτος δ' ἡ τῆς φωνῆς ἐστὶ τη γλώττῃ διάρθρωσις. τὰ μεν οὖν φωνήεντα ἡ φωνὴ καὶ ὁ λάρυγξ ἀφίησιν, τὰ δ' ἄφωνα ἡ γλῶττα καὶ τὰ χείλη· ἐξ ὧν ἡ διάλεκτός ἐστιν. p. 105. 'Αφιησι δε καὶ ὁ δελφὶς τριγμὸν καὶ μύζει—ἔστι γὰρ τούτῳ φωνὴ—ἀλλὰ τὴν γλῶτταν οὐκ ἀπολελυμένην (ἔχει) οὐδε χειλη ὥστε ἄρθρον τι τῆς φωνῆς ποιεῖν. p. 106.	L'homme a une prééminence particulière dans les organes de sa voix; il peut seul articuler des sons; la forme de sa bouche et la grande mobilité de ses lèvres en sont probablement les causes. p. 86.

APES, &c.

Aristotle.	*Cuvier*, tom. I.
The feet of apes are peculiar, and resemble large hands, the toes being like fingers, and the under surface of the hind foot like the palm of the hand, but terminating in a badly shaped heel. Hence they often use their feet as hands. Their arms resemble those of man, as also their hands, and fingers, and nails; and they bend their extremities in the same direction as man does.* The upper part of their body being larger than the lower part, as is the case with decided quadrupeds; and their feet partaking of the character of hands; their pelvis moreover, being small; they are from these joint causes incapable of continuing long in an erect position.	The hind feet of the quadrumana (to which *order* apes belong) have a thumb capable of being opposed to the other toes, which are as long and as flexible as the fingers; whence they are capable of climbing well; but they do not easily walk or support themselves in an erect position, because their pelvis is narrow, and the plane of the under surface of their feet is not horizontal.
Like man they have two mammæ on the chest; and their internal anatomy resembles the human.	In the character of their intestines, in the direction of their eyes, and in the position of their breasts, they resemble man; and the structure of their fore-arms and hands enables them to imitate us in many of their gestures and actions.
Some of the apes (πίθηκοι) resemble man in many points, as to their face: for they have nostrils and ears; and both their front and back teeth not much unlike those of man.	The higher species of apes have flat nails; and teeth very much resembling the human both in number and arrangement, and also in form: and they have no tail.
Οἱ δε πίθηκοι—ἰδίους τοὺς πόδας (ἔχουσι)· εἰσὶ γὰρ οιον χεῖρες μεγάλαι, καὶ οἱ δάκτυλοι ὥσπερ οἱ τῶν χειρῶν, ὁ μέσος μακρότατος, καὶ τὸ κάτω τοῦ ποδὸς χειρὶ ὅμοιον, πλὴν ἐπὶ τὸ μῆκος τὸ τῆς χειρὸς ἐπὶ τὰ ἔσχατα τεῖνον, καθάπερ θέναρ· τοῦτο δε ἐπ' ἄκρου σκληρότερον, κακῶς καὶ ἀμυδρῶς μιμούμενον πτέρνην. κέχρηται δε τοις ποσὶν ἐπ' ἄμφω, καὶ	Les quadrumanes diffèrent de notre espèce par le caractère très-sensible, que ses pieds de derrière ont les pouces libres et opposables aux autres doigts, et que les doigts des pieds sont longs et flexibles comme ceux de la main; aussi toutes les espèces grimpent-elles aux arbres avec facilité, tandis qu'elles

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* The same is true of quadrupeds in general: in most of which, however, Aristotle mistook the joint at the heel and wrist, for that of the knee and elbow.

Aristotle.	*Cuvier*, tom. I.
ὡς χερσὶ καὶ ὡς ποσὶ, καὶ συγκάμπτει ὥσπερ χεῖρας.—Ἔχει δε καὶ βραχίονας ὥσπερ ἄνθρωπος, πλὴν δασεῖς· καὶ κάμπτει καὶ τούτους καὶ τὰ σκέλη ὥσπερ ἄνθρωπος—πρὸς δὲ τούτοις χεῖρας καὶ δακτύλους καὶ ὄνυχας ὁμοίους ἀνθρώπῳ, πλὴν πάντα ταῦτα ἐπὶ τὸ θηριωδέστερον. Τὰ δ' ἄνω τοῦ κάτω πολὺ μείζονα ἔχει, ὥσπερ τὰ τετράποδα—καὶ διά τε ταῦτα καὶ διὰ τὸ τοὺς πόδας ἔχειν ὁμοίους χερσὶ —διατελεῖ τὸν πλείω χρόνον τετράπουν ὂν μᾶλλον ἢ ὀρθόν· καὶ οὔτ' ἰσχία ἔχει ὡς τετράπουν ὄν. p. 35, 36.	ne se tiennent et ne marchent debout qu'avec peine, leur pied ne se posant alors que sur le tranchant extérieur, et leur bassin étroit ne favorisant point l'équilibre. p. 100.
Τὰ δ' ἐντὸς διαιρεθέντα ὅμοια ἔχουσιν ἀνθρώπῳ πάντα τὰ τοιαῦτα. p. 36. Ἔχει δ' ἐν τῷ στήθει δύο θηλὰς μαστῶν μικρῶν. p. 35.	Elles ont toutes des intestins assez semblables aux nôtres, les yeux dirigés en avant, les mammelles sur la poitrine. p. 100. La liberté de leurs avant-bras et la complication de leurs mains leur permettent à toutes beaucoup d'actions et de gestes semblables à ceux de l'homme. p. 101.
Τὸ δὲ πρόσωπον ἔχει πολλὰς ὁμοιότητας τῷ τοῦ ἀνθρώπου· καὶ γὰρ μυκτῆρας καὶ ὦτα παραπλήσια ἔχει, καὶ ὀδόντας ὥσπερ ὁ ἄνθρωπος, καὶ τούς προσθίους καὶ τοὺς γομφίους. p. 35.	Les singes—ont á chaque mâchoire quatre dents incisives droites, et à tous les doigts des ongles plats ; deux caractères qui les rapprochent de l'homme plus que les genres suivans ; leurs molaires n'ont aussi, comme les nôtres, que des tubercules mousses. p. 101.

THE HEDGEHOG AND PORCUPINE.

Porcupines and land-echini, or hedgehogs, are covered with spines, which are properly to be considered in these animals as a kind of rigid and indurated hair ; for these spines do not serve the purpose of feet, as they do in sea-echini.	Hedgehogs have their body covered with quills instead of hair ; and so have porcupines.
Τριχῶν γάρ τι εἶδος θετέον καὶ τὰς ἀκανθώδεις τρίχας, οἵας οἱ χερσαῖοι ἔχουσιν ἐχῖνοι καὶ οἱ ὕστριχες· τριχός γὰρ χρείαν παρέχουσιν, ἀλλ' οὐ ποδῶν, ὥσπερ οἱ τῶν θαλαττίων. p. 10.	Les hérissons et les porcépics ont le corps couvert de piquans au lieu de poils. p. 132 et 208.

THE MOLE.

Aristotle.

All viviparous animals have eyes, except the mole; and even this animal, although it has neither the faculty of sight, nor eyes readily visible, cannot be said to be altogether without eyes; for if its skin be taken off, you may distinguish not only the natural situation of the eyes, but that black central part of the eye itself in which the pupil is contained; as if these organs had been imperfectly developed, and the skin had grown over them. If the skin, which is thick, be stripped off from the head, you may perceive on its inner surface, and in the usual region, distinct eyes; which, though small and shrunk, as it were, have all the essential parts of those organs, namely, a pupil placed in the centre of the black part of the eye, and that black part surrounded by the white.*

Ζωοτόκα πάντα (ἔχει ὀφθαλμοὺς) πλὴν ἀσπάλακος. τοῦτον δὲ τρόπον μέν τιν' ἔχειν ἂν θείη τις, ὅλως δ' οὐκ ἔχειν. ὅλως μὲν γὰρ οὔθ' ὁρᾷ οὔτ' ἔχει εἰς τὸ φανερὸν δήλους ὀφθαλμούς· ἀφαιρεθέντος δὲ τοῦ δέρματος ἔχει τήν τε χώραν τῶν ὀμμάτων καὶ τῶν ὀφθαλμῶν τὰ μέλανα κατὰ τὸν τόπον καὶ τὴν χώραν τὴν φύσει τοῖς ὀφθαλμοῖς ὑπάρχουσαν ἐν τῷ ἐκτὸς, ὡς ἐν τῇ γενέσει πηρουμένων καὶ ἐπιφυομένου τοῦ δέρματος. p. 13. 'Αφαιρεθέντος δὲ τοῦ δέρματος ὄντος παχέος ἀπὸ τῆς κεφαλῆς κατὰ τὴν χώραν τὴν ἔξω τῶν ὀμμάτων ἔσωθέν εἰσιν οἱ ὀφθαλμοὶ διεφθαρμένοι, πάντ' ἔχοντες ταὐτά τὰ μέρη τοῖς ἀληϑινοίς· ἔχουσι γὰρ τό τε μέλαν καὶ τὸ ἐντὸς τοῦ μέλανος τὴν καλουμένην κόρην, καὶ τὸ κυκλώπιον. p. 100, 101.

Cuvier, tom. I.

The eye of the mole is so small, and so concealed by the skin, that for a long time this animal was supposed to be without eyes. The blind rat-mole has no visible trace of external eyes; but in taking off the skin, a very small black point is observable, which appears to have the organization of an eye, without the possibility of being employed as such, because the skin passes over it not only in an entire state, but as thick and as closely covered with hair as in any other part of the face. This may probably be the animal which, according to M. Olivier, gave the idea to the ancients of describing the mole as totally blind.†

Son œil est si petit, et tellement caché par le poil, qu'on en a nié long-temps l'existence. p. 137. Le rat-taupe aveugle—n'a même point du tout d'œil visible au dehors: mais quand on elève sa peau, on trouve un très-petit point noir qui paraît organisé comme un œil, sans pouvoir servir à la vision, puisque la peau passe dessus sans s'ouvrir ni s'amincir, et sans y avoir moins de poils qu'autre part.—Il se pourrait, comme le dit M Olivier, qu'il eût donné aux anciens l'idée de fair la taupe toute-à-fait aveugle. p. 201.

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* Κυκλώπιον (p. 101.) is evidently synonymous with λευκόν. (p. 12)

† By an examination of Aristotle's description it is evident that the ancients knew the true state of the case, namely, that the mole has eyes.

THE BEAR.

Aristotle.

The bear is an omnivorous animal, living on various fruits, on honey, on ants, and on flesh; attacking not only the smaller animals, but even wild boars and bulls.* The feet of the bear resemble hands; and for a short time this animal can walk erect on its two hind feet.

῾Η δ' ἄρκτος παμφάγον ἐστι. καὶ γὰρ καρπὸν ἐσθίει—καί μέλι—καὶ μύρμηκας, καὶ σαρκοφαγεῖ. διὰ γὰρ τὴν ἰσχὺν ἐπιτίθεται οὐ μόνον τοῖς ἐλάφοις ἀλλὰ καὶ τοῖς ἀγρίοις ὑσὶν—καὶ τοῖς ταύροις· ὁμόσε χωρήσασα γὰρ τῷ ταύρῳ κατὰ πρόσωπον ὑπτία καταπίπτει, καὶ τοῦ ταύρου τύπτειν ἐπιχειροῦντος τοῖς μὲν βραχίοσι τὰ κέρατα περιλαμβάνει, τῷ δὲ στόματι τὴν ἀκρωμίαν δακοῦσα καταβάλλει τὸν ταῦρον. βαδίζει δ' ἐπί τινα χρόνον ὀλίγον καὶ τοῖν δυοῖν ποδοῖν ὀρθή. p. 224.

Cuvier, tom. I.

The bear though so powerful an animal is not disposed to feed on flesh, unless when compelled by want of other food. Bears walk on the whole sole of the foot, and are thus enabled to raise themselves with comparative ease in an erect position on their hind feet.

Les ours—malgré leur extrême force, ne mangent-ils guère de chair que par nécessité. Ils marchent sur la plante entière, ce qui leur donne plus de facilité pour se dresser sur leurs pieds de derrière. p. 141.

THE SEAL.

The seal brings forth its young on shore, but passes most of its time in the sea, and derives its nourishment from thence. With respect to its extremities, it may be considered as an imperfect quadruped; for immediately in succession to its shoulder blades it has feet resembling *hands;*† and on each foot are five toes, and each toe has three joints: the hind feet in their shape resemble the tail of a fish. All the teeth of the seal are sharp and pointed, as indicating

The feet of the seal are so short, and so enveloped in the skin, that on land they only serve them for crawling; but, as the interstices of the toes are filled up with membrane, they act as excellent oars; and hence these animals pass the greater part of their life in the sea, only coming to land for the purpose of basking in the sun and suckling their cubs. They have five toes on each of their feet: and on the hind feet the outermost and innermost are longest, the intermediate being

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* Its mode of engaging with the bull is thus described by Aristotle: "In engaging the bull, the bear throws itself on its back; and, while the bull is attempting to toss it, the bear takes the bull's horns between its paws, and thus overthrows its adversary."

† From the shortness of the arm and fore-arm in this animal, Aristotle overlooked these parts.

Aristotle.

the approximation of their nature to fish; almost all fish having teeth of that character. The seal has a cloven tongue.

Ἡ δὲ φώκη—τίκτει ἐν τῇ γῇ μὲν—διατρίβει δὲ τοῦ χρόνου τὸν πολὺν καὶ τρέφεται ἐκ τῆς θαλάττης. p. 167, 168. Ἡ δὲ φώκη ὥσπερ πεπηρωμένον ἐστὶ τετράπουν· εὐθύς γὰρ ἔχει μετὰ τὴν ὠμοπλάτην τοὺς πόδας ὁμοίους χερσὶν—πενταδάκτυλοι γάρ εἰσι, καὶ ἕκαστος τῶν δακτύλων καμπὰς ἔχει τρεῖς—οἱ δ᾽ ὀπίσθιοι—τῷ σχήματι παραπλήσιοι ταῖς τῶν ἰχθύων οὐραῖς εἰσί. p. 27. Καρχαρόδουν ἐστὶ πᾶσι τοῖς ὀδοῦσιν, ὡς ἐπαλλάττουσα τῷ γένει τῶν ἰχθύων· οἱ γὰρ ἰχθύες πάντες σχεδὸν καρχαρόδοντές εἰσιν. p. 33. Ἔχει δὲ—ἐσχισμένην τὴν γλῶτταν. p. 48.

Cuvier, tom. I.

shortest. All their teeth have either pointed or cutting edges. Their tongue is indented at the extremity.

Leurs pieds sont si courts, et tellement enveloppés dans la peau, qu'ils ne peuvent, sur terre, leur servir qu'à ramper; mais comme les intervalles des doigts y sont remplis par des membranes, ce sont des rames excellentes; aussi ces animaux passent-ils la plus grande partie de leur vie dans la mer, et ne viennent à terre que pour se reposer au soleil, et allaiter leurs petits. p. 163, 164. Les phoques ont—cinq doigts à tous les pieds—au pieds de derrière, le pouce et le petit doigt sont les plus longs, et les intermédiares les plus courts. Toutes les dents sont tranchantes ou coniques. p. 164 Leur langue est lisse, et échancrée au bout. p. 165.

THE ELEPHANT.

The elephant has five toes on each foot; though the joints of these are not very distinct. It has four teeth on each side of its mouth, with which it triturates its food, and makes it as smooth as bran: and besides these it has two very large teeth. It has a long and powerful proboscis, which it uses as a hand; for with this organ it takes up and conveys to its mouth both solid and liquid food. Its intestines have appendages, presenting the appearance of four stomachs: and it has two mammæ placed by the side of the chest, near the axillæ. The cub of the elephant sucks with its mouth, and not with its proboscis.

Elephants have on each foot five toes, very well defined in the skeleton, but so embedded in the callous skin enveloping the foot that they can only be recognised externally by their nails, which are attached to the edge of this hoof as it were. They have two tusks, which sometimes grow to an enormous size; and either four or eight grinding teeth on each side according to the periods of their developement. The proboscis, terminating in an appendage like a finger, gives to the elephant a degree of address equal to that which the hand of the ape imparts to that animal. The elephant uses this proboscis for the purpose of conveying solid food or pumping up liquids into its mouth. The intestines of the elephant are volumi-

Aristotle.	*Cuvier*, tom. I.
	nous; it has two mammæ placed under the breast, and its cub sucks with the mouth, and not with the trunk.
῎Εστι δὲ πενταδάκτυλον (ὁ ἐλέφας)—τά τε περὶ τοὺς δακτύλους ἀδιαρθρωτότερα ἔχει τῶν ποδῶν. p. 25. ‘Ο δ’ ἐλέφας οδόντας μὲν ἔχει τέτταρας ἐφ’ ἑκάτερα, οἷς κατεργάζεται τὴν τροφὴν (λεαίνει δ’ ὥσπερ κριμνὰ,) χωρὶς δὲ τούτων ἄλλους δύο τοὺς μεγάλους. p. 34. Τοῖς δε ἐλὸφασιν ὁ μυκτὴρ γίνεται μακρὸς καὶ ἰσχυρὸς, καὶ χρῆται αὐτῷ ὥσπερ χειρί· προσάγεταί τε γὰρ καὶ λαμβάνει τούτῳ καὶ εἰς τὸ στόμα προσφέρεται τὴν τροφὴν, καί τὴν ὑγρὰν καὶ τὴν ξηρὰν, μόνον τῶν ζῴων. p. 14. ‘Ο δε ἐλέφας ἔντερον ἔχει συμφυσεις ἔχον, ὥστε φαίνεσθαι τέτταρας κοιλίας ἔχειν· p. 47. ῎Εχει δε τοὺς μαστοὺς δύο περὶ τὰς μασχάλας—οὐκ ἐν τῷ στήθει ἀλλὰ πρὸς τῷ στήθει. p. 30 et 26. ‘Ο δε σκὺμνοςὅ ταν γένηται, θηλάζει τῷ στόματι καὶ οὐ τῷ μυκτῆρι. p. 191. Camper says that in almost all points the anatomy of the elephant is correctly represented by Aristotle; the apparent inconsistencies arising from his having dissected a *young* elephant. Tom. ii. p. 205, &c.	(Les éléphans) ont cinq doigts à tous les pieds, bien complets dans le squelette, mais tellement encroutés dans la peau calleuse qui entoure le pied, qu'ils n'apparaissent au dehors que par les ongles attachés sur le bord de cette espèce de sabot. p. 228, 229. Deux défenses qui sortent de la bouche et prennent souvent un accroissement énorme. p. 229. Tantôt une, tantôt deux mâchelières de chaque côté, quatre ou huit en tout, selon les époques. p. 231. Une trompe cylindrique—terminée par un appendice en forme de doigt—donne à l'éléphant presque autant d'adresse que la perfection de la main peut en donner au singe. Il s'en sert pour saisir tout ce qu'il veut porter à sa bouche et pour pomper sa boisson. p. 229. Les intestins sont très-volumineux—les mammelles, au nombre de deux seulement, placées sous la poitrine. Le petit tette avec la bouche et non avec la trompe. p. 230.

RUMINATING ANIMALS.

All viviparous quadrupeds which have horns are without the front teeth in the upper jaw; and some indeed which have no horns have the same defect with respect to the teeth, as the *camel.*	With the exception of the *camel* and the musk, all the animals of this order have horns; and all are without front teeth in the upper jaw.
Of viviparous quadrupeds some are cloven-footed and have hoofs instead of claws, as the ox, sheep, goat, and deer. The same animals have four stomachs, and are said to ruminate.	The feet terminate in two toes, each of which is covered with a separate hoof, and is opposed to its fellow by a flat surface; from whence they are called cloven-footed. The animals of this order are called *ruminating;* and have always four stomachs.

Aristotle.	*Cuvier*, tom. I.
With the exception of the deer, all ruminating animals have horns which are partly hollow, and partly solid; the hollow part grows out of the skin, of which it is indeed a continuation; but that part round which this hollow is fitted is solid, and grows out of the bone; as in oxen.	The structure of the horns differs in different species. In some the solid osseous part which projects from the frontal bone is covered with a hollow case, which grows over it from the skin, as in oxen, sheep, and goats.
The horns of most animals are, in their form, simple, and are hollow, except at their extremity; the horns of the deer alone are in their form arborescent; and, in their substance, solid throughout.	
The deer alone, from the age of two years, sheds its horns annually; the horns of other animals are permanent, unless separated by violence. Deer at the age of one year have merely the rudiments of horns, short sprouts, as it were, covered with downy skin. At the age of two years they develope straight horns like wooden pegs; and are hence called at that period παττaλίαι.	In the various species of deer the osseous projections are covered, during their growth, with skin resembling that of the rest of the head. This skin subsequently perishes, leaving the osseous horn uncovered; and, after a time, the horns themselves are shed; and are succeeded by others which are usually larger than the preceding; and these again are shed in their turn and replaced by others.
At three years their horns have two branches; at four years, more; and in this way the number of branches increases till the animal is six years old; after which the number is not increased.	The figure of the horn in deer varies according to the age and species of the animal.
The horn at first grows as it were in the skin, and has a soft villous covering; and after it has attained its full growth the animal exposes itself to the sun, in order to ripen and dry up this covering.	
Τετράποδα ἔναιμα καὶ ζῳοτόκα—ὅσα μεν ἐστὶ κερατοφόρα, οὐκ ἀμφώδοντά ἐστιν· οὐ γὰρ ἔχει τοὺς προσθίους ἐπὶ τῆς ἄνω σιαγόνος. ἔστι δ' ἔνια οὐκ ἀμφώδοντα καὶ ἀκέρατα, οἷον κάμηλος. p. 32.	Les ruminans—ont l'air d'être presque tous construits sur le même modèle, et les chameaux seuls présentent quelques petites exceptions aux caractères communs. Le premier de ces caractères est de n'avoir d'incisives qu'à la mâchoire inférieure. p. 246. Toute le reste de ruminans (ex-

Aristotle.	*Cuvier*, tom. I.
	cepté les chameaux, &c.) a, au moins dans la sexe mâle, deux cornes, c'est-à-dire, deux proéminences plus ou moins longues des os frontaux. p. 252.
Τῶν δε τετραπόδων καὶ ἐναίμων καὶ ζῳοτόκων τὰ μέν ἐστι—δισχιδῆ, καὶ ἀντὶ τῶν ὀνύχων χηλὰς ἔχει, ὥσπερ πρόβατον καὶ αἲξ καὶ ἔλαφος καὶ βοῦς. p. 29.	Les quatre pieds sont terminés par deux doigts et par deux sabots, qui se regardent par une face aplatie, en sorte qu'ils ont l'air d'un sabot unique, qui aurait été fendu. p. 246.
Καὶ τέτταρας ἔχει ἀνομοίας κοιλίας· ἃ δὴ καὶ λέγεται μηρυκάζειν. p. 46.	Le nom de ruminans indique la propriété singulière de ces animaux, de mâcher une seconde fois les alimens—propriété qui tient à la structure de leurs estomacs. Ils en ont toujours quatre. p. 247.
Τῶν δ' ἐχόντων κέρας δι' ὅλου μὲν ἔχει στερεὸν μόνον ἔλαφος, τὰ δ' ἄλλα κοῖλα μέχρι τινός, τὸ δ' ἔσχατον στερεόν. τὸ μὲν οὖν κοῖλον ἐκ τοῦ δέρματος πέφυκε μᾶλλον. περὶ δὲ [ὃ]* τοῦτο περιήρμόσται τὸ στερεὸν ἐκ τῶν ὀστῶν, οἷον τὰ κέρατα τῶν βοῶν. p. 30. Τῶν δὲ κερὰτων τὰ μὲν πλεῖστα κοῖλά ἐστιν ἀπὸ τῆς προσφύσεως περὶ τὸ ἐντὸς ἐκπεφυκὸς ἐκ τῆς κεφαλῆς ὀστοῦν, ἐπ' ἄκρου δ' ἔχει τὸ στερεὸν, καὶ ἔστιν ἁπλᾶ· τὰ δὲ τῶν ἐλάφων μόνα δι' ὅλου στερεὰ καὶ πολυσχιδῆ. p. 67, 68. 'Αποβάλλει δὲ τὰ κέρατα μόνον ἔλαφος κατ' ἔτος, ἀρξάμενος ἀπὸ διετοῦς, καὶ πάλιν φύει· τὰ δ' ἄλλα συνεχῶς ἔχει, ἐὰν μή τι βίᾳ πηρωθῇ. p. 30. Οἱ μὲν οὖν ἐνιαύσιοι οὐ φύουσι κέρατα, πλὴν ὥσπερ σημείου χάριν ἀρχήν τινα· τοῦτο δ' ἐστὶ βραχὺ καὶ δασύ. φύουσι δὲ διετεῖς πρῶτον τὰ κέρατα εὐθέα, καθάπερ παττάλους· διὸ καὶ καλοῦσι τότε πατταλίας αὐτούς. Τῷ δὲ τρίτῳ ἔτει δίκρουν φύουσι, τῷ δὲ τετάρτῳ τραχύτερον· καὶ τοῦτον ταν τρόπον ἀεὶ ἐπιδιδόασι μέχρι ἓξ ἐτῶν. ἀπὸ τούτου δὲ ὅμοια ἀεὶ ἀναφύουσιν. p. 258. Τὰ δὲ κέρατα	Dans le genre des bœufs, &c. les cornes sont revêtues d'un étui—on donne en particulier le nom de *corne* à la substance de cet étui, et lui-même porte celui de *corne creuse*. p. 252. Dans le genre des cerfs, les proéminences couvertes pendant un temps d'une peau velue comme celle du reste de la tête, ont à leur base un anneau de tubercules osseux, qui, en grossissant, compriment et oblitèrent les vaisseaux nourrissiers de cette peau. Elle se dessèche et est enlevée; la proéminence osseuse mise à nu, se sépare au bout de quelque temps du crâne auquel elle tenait; elle tombe, et l'animal demeure sans armes. Mais il lui en repousse bientôt de nouvelles, d'ordinaire plus grandes que les précédentes, et destinées à subir les mêmes révolutions. Ces cornes, purement osseuses, et sujettes à des changemens périodiques, portent le nom de *bois*. p. 253. La

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* There can be no doubt from the structure of the horns of oxen, &c. that the relative (ὁ) ought to be retained; and the τὸ κοῖλον ἐκ τοῦ δέρματος is evidently opposed to the τὸ στερεὸν ἐκ τῶν ὀστῶν. But the question is quite settled by the following passage from p. 67, τῶν δὲ κεράτων, κ. τ. λ.

Aristotle.	*Cuvier*, tom. I.
φύεται ὥσπερ ἐν σέρματι τὸ πρῶτον, καὶ γίνονται δασέα· ὅταν δ' αὐξηθῶσιν, ἡλιάζονται, ἵν' ἐκπέψωσι καὶ ξηράνωσι τὸ κέρας. p. 259.	figure de ce *bois* varie beaucoup—selon l'âge. p. 254.

CETACEOUS ANIMALS.

The dolphin and whale and other cetaceous animals, which have not gills, but a tube for conveying away the sea-water received into their mouth, are viviparous; and they respire air, for they have lungs: and hence, if caught in a net, and unable to come to the surface for the purpose of breathing, they are suffocated.	Cetaceous animals remain constantly in the water; but, as they respire by means of lungs, they are obliged to come often to the surface for air. p. 272. The ordinary cetacea possess a remarkable apparatus, from which they are called *blowers*, by means of which they discharge through their nostrils a large volume of water which they take into their mouth with their food. p. 275.
The dolphin utters a kind of murmur when it is in the air; for it has a voice, inasmuch as it has lungs, and an air-tube leading to them; but having no lips, and its tongue being not sufficiently moveable, it is unable to utter an articulate sound.	They have no prominent laminæ in their glottis; and hence their voice is nothing more than a simple lowing. p. 276.
The dolphin has mammæ, not placed in the anterior part of the body, but near the vent.	Their mammæ are placed near the vent. p. 276.
The mildness and docility of the dolphin are remarkable.	The general organization of the dolphin's brain shows that it possesses the docility usually attributed to it. p. 278.
These fish swim in large flocks, and their swiftness is so remarkable that they have been known to spring over the decks of ships.	The common dolphin, which is found in large flocks in every sea, and is remarkable for its swiftness of motion, so that it occasionally darts over the decks of ships, appears evidently to be the dolphin of the ancients. p. 278.
The cetaceous animal called mysticetus has no teeth, but hairs instead, like hogs' bristles.	The upper jaw of the balænæ is furnished with thin transverse laminæ closely set, formed of a kind of fibrous horn terminating in a bristly fringe at the border. p. 284.

Aristotle.	*Cuvier*, tom. I.
Δελφὶς δὲ καὶ φάλαινα καὶ τὰ ἄλλα κήτη, ὅσα μὴ ἔχει βράγχια ἀλλὰ φυσητῆρα, ζωοτοκοῦσιν. Ἀναπνεῖ δὲ πάντα ὅσα ἔχει φυσητῆρα, καὶ δέχεται τὸν ἀέρα· πλευμονα γὰρ ἔχουσίν. p. 167. Διὸ καὶ λαμβανόμενος ὁ δελφὶς ἐν τοῖς δικτύοις ἀποπνίγεται ταχέως διὰ τὸ μὴ ἀναπνεῖν. p. 215.	Les cétacés se tiennent constamment dans les eaux ; mais comme ils respirent par des poumons, ils sont obligés de revenir souvent à la surface pour y prendre de l'air. p. 272. Les cétacés ordinaires se distinguent par l'appareil singulier qui leur a valu le nom commun de *souffleurs*. C'est qu'engloutissant, avec leur proie, de grands volumes d'eau, il leur fallait une voie pour s'en débarrasser; elle s'amasse dans un sac placé à l'orifice extérieur de la cavité du nez, d'ou elle est chassée avec violence—au travers d'une ouverture percée au-dessus de la tête. p. 275, 276.
Ἀφίησι δὲ καὶ ὁ δελφὶς τριγμὸν καὶ μύζει, ὅταν ἐξέλθῃ, ἐν τῷ ἀέρι—ἔστι γὰρ τούτῳ φωνή· ἔχει γὰρ καὶ πλεύμονα καὶ ἀρτηρίαν, ἀλλὰ τὴν γλῶτταν οὐκ ἀπολελυμένην οὐδὲ χείλη ὥστε ἄρθρον τι τῆς φωνῆς ποιεῖν. p. 106.	Il n'y a point de lames saillantes dans leur glotte, et leur voix doit se réduire à de simples mugissemens. p. 276.
Ὁ δελφὶς ἔχει μαστοὺς δύο, οὐκ ἄνω δ' ἀλλὰ πλησίον τῶν ἄρθρων. p. 40.	Leurs mamelles sont près de l'anus. p. 276.
Τῶν δὲ θαλασσίων πλεῖστα λέγεται σημεῖα περὶ τοὺς δελφῖνας πραότητος καὶ ἡμερότητος. p. 301.	Toute l'organisation de son cerveau annonce que le dauphin ne doit pas être dépourvu de la docilité que les anciens lui attribuaient. p. 278.
Ἤδη δ' ὦπται δελφίνων μεγάλων ἀγέλη ἅμα καὶ μικρῶν. Λέγεται δὲ καὶ περὶ ταχυτὴτος ἄπιστα τοῦ ζῴου· ἁπάντων γὰρ δοκεῖ εἶναι ζῴων τάχιστον, καὶ τῶν ἐνύδρων καὶ τῶν χερσαὶων, καὶ ὑπεράλλονται δὲ πλοὶων μεγάλων ἱστούς. p. 302.	Cet animal, répandu en grandes troupes dans toutes les mers, et célèbre par la vélocité de son mouvement, qui le fait s'élancer quelquefois sur le tillac des navires, paraît réellement avoir été le dauphin des anciens. p. 278.
Ἔτι δὲ καὶ ὁ μῦς τὸ κῆτος ὀδόντας μὲν ἐν τῷ στόματι οὐκ ἔχει, τρίχας δὲ ὁμοίας ὑείαις. p. 72.	La mâchoire supérieure—a ses deux côtés garnis de lames transverses minces et serrées,—formées d'une espèce de corne fibreuse, effilées à leur bord. p. 284.

From the preceding comparison it appears that, with respect to those points in the history of animals, the knowledge of which was equally accessible to both writers, the descriptions of Aristotle are hardly inferior in accuracy to those of Cuvier. Nor does this observation hold with reference to the more common animals only: it is equally remarkable with reference to those which are of comparative rarity; in support of which assertion I would refer, among other instances, to the description of the sepia, and of the chameleon, and of the evolution of the egg of the bird during incubation. But I have perhaps already extended this comparison too far, and will therefore here conclude.

THE END.

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